ARCHAEOLOGY AND ARCHAEOLOGICAL INFORMATION IN THE DIGITAL SOCIETY

Edited by
Isto Huvila

Archaeology and Archaeological Information in the Digital Society

'This collection of papers by information scientists and archaeologists offers many new insights into what it means to study the past within today's digital world. Focussing on how computers impact on the production of knowledge and the social context of digital archaeology, this book raises important issues that should be of central concern to all of us interested in archaeology and what it means to practice it.'

Gary Lock, *University of Oxford*

Archaeology and Archaeological Information in the Digital Society shows how the digitisation of archaeological information, tools and workflows, and their interplay with both old and new non-digital practices throughout the archaeological information process, affect the outcomes of archaeological work, and in the end, our general understanding of the human past.

Whereas most of the literature related to archaeological information work has been based on practical and theoretical considerations within specific areas of archaeology, this innovative volume combines and integrates intra- and extra-disciplinary perspectives to archaeological work, looking at archaeology from both the inside and outside.

With fields studies from museums and society, and pioneering new academic research, *Archaeology and Archaeological Information in the Digital Society* will interest archaeologists across the board.

Isto Huvila holds the chair in information studies at the Department of ALM (Archival Studies, Library and Information Science and Museums and Cultural Heritage Studies) at Uppsala University, Sweden and is adjunct professor (docent) in information management at Åbo Akademi University, Finland. His research focuses on information and knowledge management, organisation and documentation, and social and participatory information practices. He has published broadly on these topics as well as social media, ancient history and archaeology. He received a MA degree in cultural history at the University of Turku in 2002 and a PhD degree in information studies at Åbo Akademi University, Finland in 2006.

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Bodil Petersson, PhD, is associate professor of Archaeology at the Department of Cultural Sciences, Linnaeus University in Kalmar, Sweden. She has researched and published on topics such as archaeological reconstruction and re-enactment, experimental archaeology, time travel, digital heritage communication, the history of archaeology and the role of archaeology in contemporary society. During the years 2013 to 2017, she was co-researcher in the Archaeological Information in the Digital Society project (ARKDIS) funded by the Swedish Research Council. Since autumn 2014, she has been program director of the Bachelor's Programme in Heritage in Present and Future Society at Linnaeus University. At present, she is conducting a project on experimental heritage, a research field and collaboration project involving researchers, artists and heritage workers, which explores the relation between art and archaeology/heritage in local society.

Per Stenborg (Ph.D. 2001, University of Gothenburg) is associate professor and researcher at the Department of Historical Studies, University of Gothenburg.

Over the last 25 years he has carried out several archaeological research projects in different parts of South America, including as the project director of the Cultivated Wilderness Project. He has also done research about how archaeology and cultural heritage management may use digital and computer-based technologies in presenting and communicating their results and products and how, in turn, these technologies change the archaeological practice and the understanding of history.

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You are never writing a book alone. This applies especially to books written to round up findings, observations and insights of a four-year long project during which we have had the opportunity to have extended discussions in our archaeological information in the digital society project group and with those numerous guests we have visited and those who have visited us. Taking the risk that it sounds self-centred, as a group, we would like to thank each other for the opportunity to work and discuss with each other all these years. We have all learned a lot on archaeology, archaeological information work and much more. You, no, we, have been a wonderful group to work with.

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Abbreviations

ARKDIS	Archaeological information in the digital society (research project)
CAA	Computer Applications and Quantitative Methods in Archaeology
CAB	County Administrative Board
EAA	European Association of Archaeologists
GPS	Global Positioning System
SAA	Society for American Archaeology
TAG	Theoretical Archaeological Group

Introduction

Isto Huvila

There is no digital archaeology and no digital society. There is merely archaeology and society, and the digital is a facet of a particular set of technologies and a cultural phenomenon that permeates contemporary existence both when it is present and when it is absent. In contrast to earlier perspectives to archaeology and the digital, this edited volume explores the impact of digitality on archaeological work in a societal context. Instead of looking at the impact of digitality in archaeological theory and practice, we go further to see what happens in society when the digital instils archaeological practices and their premises and vice versa, and how archaeological practices are influenced by how 'the digital' has permeated contemporary culture. For us, the outcome of digitality on archaeology does not stop at a conceptualisation of a possible new digital paradigm but at a careful explication and understanding of how it changes the very essence of what archaeologists do.

This book traces the interplay of digital changes and non-digital stabilities throughout the archaeological information process from the field to academic research, museums and society. As for archaeology (e.g. Alberti et al., 2013; Edgeworth, 2015; Meskell, 2005; Witmore, 2014), information in this volume is as much material, visual, cognitive, social, oral and embodied as it is textual. The individual chapters look into how the management, use and reuse of information and knowledge-making are changing and what implications the changes have on what we know about archaeology and the past. As Stenborg notes later in this book, 'archaeology may be considered as a discipline concerned with knowledge or information about the past', but as much as being concerned about the past, as a whole, this volume extends its scope to the interest in information and knowledge about the archaeological enterprise. To come closer to this, the different chapters of this volume explore not only the implications of knowing and not knowing about the past but also what access and information means in different existing and emerging contexts of use. The long-term concern of archaeology, and this volume alike, is not only how archaeological information work happens here and now but also what are its prospects of perpetuation, that is, consequences for knowledge-making in the future.

The digital change is partly a very tangible and partly an imagined shift of changing priorities and perspectives. It is intertwined with societal politics and

practices of conducting and using research, defining and valuing cultural heritage, and, for instance, keeping and managing archival information. Closer to the everyday practices working with archaeology, it is shaped by organisational and disciplinary change and inertia, the persistence of enduring qualities of archaeological work, the longevity of how and what is known about archaeology in the future, how the digital influences archaeological work, and especially its repercussions in other branches of archaeological work and more broadly in society, and what are the central skills and competences of archaeologists and non-archaeologists working with archaeology and archaeological information.

At the same time as we posit that digital archaeology or digital society do not exist, we ask whether digitality and its wider implications for research make a paradigm shift (e.g. Kristiansen, 2014a), a scientific intellectual movement (Frickel & Gross, 2005) or a mere appropriation of a particular set of technologies in the use of the perennial enterprise of doing archaeology. The conclusion might be that it is of that all but nothing of it in particular. It will have the role it will be given.

Using a set of glimpses to different parts of the archaeological information process and the influence of digital in the archaeological work from archaeological fieldwork to the desks of administrators and large-scale data intensive research to museums and global audiences of archaeological heritage, this volume seeks answers to the following:

- How the concept of archaeological information is changing and is not changing.
- How digital technologies for documentation and knowledge-making impact the types of information valued today, and the types of information kept for future uses.
- What should be done with archaeological work and the management of archaeological information to make the best out digitality and to avoid the worst?

These questions will be discussed in the following seven chapters of this volume. The aim of this volume is not to provide a comprehensive, total overview of archaeological practices, but rather by making excursions to some of the central areas of archaeology within which the digital is making a difference, to shed light to its implications on archaeological information work. By bringing together insights from these specific areas of archaeological work, it is possible to get an idea of the impact of the digital and to understand the mechanics of archaeological information in the digital society. Central themes for all of the chapters is the diversity of archaeological information, how archaeological information is made in different contexts and situations and what are the implications of the digitisation of archaeological information work.

There are obviously limitations to what is covered in this volume. Even if there is a tendency to write internationally about archaeology and archaeological work, and to make propositions of its theoretical and practical premises and exploits,

there is really no such thing as archaeology in general. There are principles and similarities in both theoretical and practical perspectives and undertakings, but at least as many differences that make archaeologists work differently in different parts of the world, and even in different places and contexts within one country or locality. As the writers of this volume are all based in Sweden, we are well aware that much of our empirical observations and theoretical implications of our work stem from the Swedish and Nordic context. Even if all of us have been working to different extents in and on archaeologies, as well as on archaeologist and archaeological information work outside this specific area by conducting field-work in different parts of the world, or by conducting research that pertains to areas and conditions outside Scandinavia, we are aware that our perspective comes from our specific backgrounds and of the consequent limitations. In practice, all observations and propositions we make might not be equally per-tinent in all possible contexts and situations around the globe. We strongly encourage the reading of this volume as critically as all archaeological and other scholarly literature should be read when it comes to the general applicability of its propositions.

A second limitation relates to the range of themes discussed in this volume. We do write only a little about artefacts and only very specific aspects of them, and we almost omit the management of physical collections. We write about fieldwork but only from specific perspectives. The same applies to public and community archaeology. We are writing about the use and reuse of legacy archaeological data in the context of the management and archiving of archaeological information and specific lines of data intensive archaeological research. Everything written in the volume has implications to the education and training of archaeologists, even the perspective itself goes implicitly through the volume. All of these and many other topics and perspectives are facing the implications of digitisation. Archaeological information work is conducted in these contexts as well, and it is no less central to the contemporary archaeological work than the themes dis-cussed in more detail in this volume. We could have selected the topics otherwise, but we do feel that insights into this particular combination of partly typical and partly uncommon vantage points can serve as a useful onset to understanding the dynamics of archaeological information work in the contemporary, digital society.

Before starting our perusal of these issues in detail, it is necessary to discuss briefly our take on what is meant by archaeological information and making of information, what is archaeological work and what we mean when we are referring to the digital society as a scene for the digitisation of archaeological information work.

Knowledge in the making

A fundamental aim of archaeology, and of archaeological information work as an informational layer or second-order activity related to archaeological work, is to create new knowledge of past human activities. The exact definitions of what

archaeology is about vary to a certain extent, but on a fundamental level, describing archaeology as a knowledge-creating enterprise is uncontroversial. Archaeological work itself consists much more than mere knowledge production. Our definition of archaeological work in this book draws from an understanding of work as a 'distinct evolving set of inter-linked human activities with either explicitly or implicitly understood purpose, meaning and value' (Huvila, 2008). A general understanding of what counts as work is generally shared in a community, but the more specific understanding of its meaning can differ between individuals (Star & Strauss, 1999). In this volume, archaeological work covers all purposeful engagement with and for archaeology, within which, as noted earlier, knowledge creation is a central aspect. Knowledge creation is, of course, not unique to archaeology. It pertains to science, scholarship and numerous branches of professional and leisurely activities, even if in many cases, the knowledge-oriented enterprise is intertwined to more practical and tangible aims.

In this volume, our interest is information and especially the activities of informing and getting informed as a part of the knowledge generating endeavour in archaeology. However, instead of focussing on knowledge production as an ultimate aim of all archaeological work and how archaeology as a whole creates new knowledge, the pivotal point of our attention is how the production of knowledge is entwined in the mundane practices throughout the archaeological enterprise. Our interest lies on various types of local and situated acts and activities of *knowledge-making* (Börjesson et al., 2016), information work as a premise of these activities and only secondarily on how they influence the grand endeavour of *producing* archaeological knowledge as a whole. In contrast to the larger organisational knowledge producing processes (Li et al., 2017), information research only rather recently engaged in a more systematic inquiry into the particulars of these often mundane and invisible practices. Even if we are acknowledging that the making of knowledge is about producing ontologies (Nickel, 2015), in contrast to the concern of theoretical archaeology in the ontologies themselves, our interest lies in how they are made to come into being. In order to understand how a discipline such as archaeology produces knowledge, it is necessary to study how individuals and organisations acting within that discipline engage in the specific and hands-on, albeit still highly political (Nickel, 2015), micro-level practices of making the ingredients (e.g. data, Tempini, 2015, or information, Huvila, 2012b) and premises of knowledge, and the knowledge itself. In this sense, archaeological information is an ingredient of archaeological knowledge and that of the perpetuation of archaeology as a discipline, similar to how information in general is an 'ingredient' of knowledge (Huvila, 2012b), and knowledge-making is a part of archaeological information work. In practice, this information can be many things as earlier research has shown. Archaeologists and other users of archaeological information are informed by a broad range of things from printed, digital and oral to embodied sources and archaeological sites and artefacts (e.g. Huvila, 2006, 2014a; Olsson, 2016; Zahlouth & de Paiva, 2012).

What is then knowledge-making in practice? As the examples throughout the book demonstrate, knowledge-making happens everywhere, and it is a part of the

social conduct and materialities of doing archaeology (similar to how it is a part of scholarly practices in general, Barad, 2007). There is certain disagreement on whether archaeology should be seen primarily as a discipline that produces 'knowledge from inside' (Ingold, 2016) at the moment of first observation (like anthropology), or whether it is a discipline based on revisiting those observations documented for later analysis and use (Hicks, 2016b). A valid remark is that the primary observations are also made on another kind of 'archive', that of archaeological traces (Olivier, 2015). Instead of one of the extremes, a closer look at archaeological work both in the chapters of this volume and elsewhere in the literature, shows rather convincingly that archaeologists do both – which does not negate the relevance of debating the primacy of visiting or revisiting because there is a fundamental difference between examining the theoretical under-pinnings of archaeological inquiry and explicating how archaeologists are working in practice. Even if it can be debated whether archaeology is, for instance, 'the study of the past at the present' (Edgeworth, 2006, p. xi) or the 'temporality of landscape revisited' (Hicks, 2016a, p. 34) as Hicks (2016a) does, in practice, the debate shows archaeologists can do both. There is no doubt that visiting a site and observing in person has a special role in archaeological knowledge-making but at the same time, it is equally apparent that the *longue durée of* archaeological or archaeology-related knowledge-making only starts when someone engages in (archaeological) fieldwork, makes first observations and produces documentation. If not forgotten, the documentation (in some texts, e.g. Hicks, 2016b, 'archaeological knowledge') ends up in a continuum (Upward, 2000; Upward et al., 2013) of organising, managing, use and reuse similar to how archival records have many parallel lives and uses instead of one singular life cycle (McKemmish, 2001).

The forthcoming examples in this volume show that even if archaeology can be described as a discipline with a passion for collecting (e.g. Shanks, 2012), not only in theory but also in practice, the practical archaeological knowledge-making is equally ambivalent in its rapport with the use of these collections in its disciplinary enterprise of making knowledge than the theorists (e.g. Baird & McFadyen, 2014; Edgeworth, 2006, 2016; Hicks, 2016a, 2016b; Ingold, 2016). Similar to how most things can be informative but not everything is information (Buckland, 1991), not all things are equally central or valuable for knowledge-making (Bazerman, 2012). The socio-material practices of making knowledge are conditioned and manifested by theoretical paradigms, policies on both disciplinary and societal levels, and politics of disciplinary practices (Epstein, 2003). Similarly, knowledge-making is framed by the multiple contexts of its making, makers and projected uses. At the same time, however, the materialities and premises of knowledge-making itself have an influence on theoretical developments. Even if there was no direct causality between postmodern ideals and digital practices (Hand, 2008), or the emerging of new types of information and paradigmatic changes in a scholarly discipline (Kristiansen, 2014b), they are not disconnected (Huvila, 2014b).

In addition to the context within which it is happening, Haviland and Mullin (2009) point to another pertinent locus of knowledge-making, namely to those

who are making knowledge. As a form of work and 'epistemic design' (Cope & Kalantzis, 2011a) referring both to the design of a thing (as a noun), that is, its morphology, and to the act of making or marking out (Lat. *designare*) knowledge (Cope & Kalantzis, 2011a), knowledge-making is a form of authoring (Haviland & Mullin, 2009), which is performed by someone and attached with particular, yet varying forms of authorship (Huvila, 2012a) that pertain not only to knowledge as metaphorical creating and making of knowledge but to how embodied artisanal acts of making knowledge can be literally generative of new ways of interacting with the world (Smith, 2004). In archaeology, the role of field directors or academic researchers as knowledge-makers is hardly disputed but the chapters in this book show that in archaeology, similar to knowledge-making in other disciplines (Haviland & Mullin, 2009), there are a large number of invisible or half-visible knowledge-makers with less clear and well-articulated roles.

One particularly relevant question is, of course, why certain knowledge-makers and why some practices of knowledge-making are less visible than some others. A partial answer is that practices remain visible unless they are articulated and individuals involved in them are engaged in articulation work (Strauss, 1988), to quote Suchman (1995), 'making work visible'. Morville (2014), a consultant and information architect, offers two other simultaneously simple and complex explanations: human nature and organisational culture. People are impatient when they are attempting to cope with their lives and seek fast, simple and most often, in practice, partial solutions, whereas organisations have a tendency to have been built to function like machines composed of dedicated experts working detached from, and unaware of, each other without a clear idea of the whole and its constituents, whether they are people or something else.

Digitisation and digital society from the perspective of archaeological knowledge-making

An aspect of knowledge-making that is especially significant in the context of this volume is the intimate relation of knowledge-making and the modes or technologies of representing knowledge and its ingredients. Even if it is easy to exaggerate the impact of digital technologies in the context of archaeological work, there is no doubt that many things have changed and are changing. Digitality is both as insatiable and inescapable as Galloway (2014) claims, but also misused (Brattli, 2016) to an extent that it has almost become a non-term. As we suggested earlier in this introduction, it may be a part of a broad, perhaps paradigmatic, or at least substantial, shift related to information and knowledge-making in one way (e.g. as it is discussed in this volume) or another (Roosevelt et al., 2015), or as others have suggested, it may be related to a broader on-going shift of the scholarly paradigm (e.g. Kristiansen, 2014a) in archaeology. Many aspects from big data to advanced visualisation technologies are changing how archaeology can be done. What is apparent, however, is that we do still know rather little about how digital technologies are influencing work in many sectors of life. Even if written as a remark of the current limitations of the activity

theoretical approach, Lompscher's (2006) decade-old observation of the limits of contemporary research effort to 'grasp the principal far-reaching role of the computer and the Internet for society and for all kinds of human activity' (Lompscher, 2006, p. 49) could be expanded beyond computers and the Internet, and that of the specific theoretical approach to research about digitality. Digital mediation of archaeological information is changing how archaeology can be experienced and we know some of the problems with many digital approaches (Boast & Biehl, 2011), but we know still relatively little about what is being mediated and how it should be valued and trusted in terms of authenticity and realism. Is digital leading to a very particular digital version of the past or bringing the past closer to us?

In contrast to opposite claims and high hopes, digital tools have not reduced the time required for learning (Cook et al., 2010). The nearly ubiquitous access to information (Dutton, 2007) has not significantly simplified how we make decisions (Fioroni & Titterton, 2009, p. 89). Simultaneously, phenomena such as the open access and open data movements show that ubiquitous access is, to a varying degree, a reality and a promise that comes closer when an increasing number of resources become freely available for everyone and creates distance every time a new paywall or limitation to universal access is erected. What has happened is that digital information technologies have begun to change the assumptions of how things are and should be knowable (Huvila, 2012b), what and how information, information sources and infrastructures should be trusted (Sundin & Carlsson, 2016) and whether information work is to be considered as a rational, emotional or 'everyday-rational' enterprise (Huvila, 2016a). In this broader sense, the impact of digitisation and that of 'the digital' as a form of technology is functioning on a cultural and societal level rather than on an individual or a technical level.

Typical literary references to the notion of the digital as a quality of the contemporary society can be criticised for their lack of clarity, and consequently, their limited usefulness as analytical concepts. However, also the opposite, very specific attempts to dissect the notion of the digital society may be missing a point in their demand of a highly literal understanding of digitality and its role in social intercourse. Characterising our contemporary society as 'The Digital Society' can be criticised because the present society is not constituted by the digital and its essential aspects are not an outcome of digital technology (Martin, 2008). Our take on the notion in this volume is slightly less rigid. For us, the digital society is a context characterised by the ubiquity of 'the digital' within which archaeological practices and information work take place rather than as an essentialistic entity. It is a powerful metaphor that can stand as a reminder that digital technologies and 'the digital' as a technology has had, and is having, an incontestable, either direct or indirect, impact on virtually all human pursuits, including archaeological work. Precisely because digital technologies and the metaphor both participate in attaching meaning to contemporary society, we find that the notion of the digital society is a useful conceptual tool for underlining the societal aspects of digitality in the contemporary context and to emphasise how archaeological work is

conditioned by the digital not only within archaeology but also in a wider societal context.

The emergence of digital technologies has obvious implications in the context of knowledge-making. Cope and Kalantzis (2011b) suggestion that 'the transition from print to digital text has the potential in time to change profoundly the practices of knowledge-making, and consequently knowledge itself' does not apply only to text but also all other modes or technologies involved in the process. Much of knowledge-making in contemporary society is conditioned by pre-digital practices both in archaeology (Huvila, 2016b) and beyond (Cope & Kalantzis, 2011b), but in contrast to suggestions made some years ago, there are not only tentative possibilities (Cope & Kalantzis, 2011b), but also actual indications that even academic and professional knowledge-making practices might be changing. General patterns of knowledge-making in society are following the logic of the convergence culture (Jenkins, 2006, 2014), the culture of participation (Huvila, 2012b) or the (affective) capitalism of knowing (Huvila, 2016a), and to a certain extent, it seems that knowledge-making is becoming more dynamic, participatory, responsive and recursive (Cope & Kalantzis, 2011a), and chains of trust become more convoluted (Davidson & Goldberg, 2010), even in academic and professional contexts. Still, it would be wrong to assume that the influence of the digital in the context of specific disciplinary practices would be as uncomplicated as that, or that it would be good or bad *per se*.

On terminology

As already stressed, this book is about archaeology as much as it is a book in archaeology. We, as the authors of this volume, write about *archaeological practices* in a broader sense rather than as a reference to mere field practices. In some of the chapters, references to specific practice theories (e.g. how the notion is used by Pickering, 1995) are more explicit, whereas others refer to them in a more general sense. Instead of trying to define a fundamental archaeological practice (cf. e.g. Aitchison, 2007, who notes that different archaeologists have different ideas of what constitutes 'archaeological practice'), our interest is in the diversity of different practices archaeologists are engaged in.

The different chapters also refer to *archaeological documentation*. Similar to, for instance, Gardin, documentation (the outcomes of something being documented) is in this volume considered to be a superordinate concept, and data is seen as one type of what is documented in and about archaeology. However, what is acknowledged here is that *archaeological data* can be many things and many things can be archaeological data. With this concept, this volume is probably the most incoherent and vague as archaeological data is understood rather loosely as anything that can function as an ingredient for archaeological information and knowledge, however, without a capability to directly inform anyone.

The understanding of documentation comes close to how the term is used in documentation studies (Lund, 2010). Documentation (as noun) is an outcome of documentation (verb and activity) of something by someone. In an archaeological

context, it is often a question of documenting observations during a field or lab-
oratory investigation and documenting how these observations were done. As
several of the chapters in this volume show, documentation is done and created as a
part of many other types of archaeological activities from archiving to exhibition
design and beyond, either directly or indirectly. Similar to how we write about
archaeological practices and other concepts, instead of trying to reach a full con-
sensus, we have strived to a general shared understanding, however, maintaining
eventual nuances in how each of us perceive and use concepts to convey our views.

Chapters

This volume consists of eight chapters written by the members of the Archae-
ological Information in the Digital Society research project funded by the
Swedish Research Council grant 'Digitized Society – Past, Present, and Future'.
Of the authors, Dell'Unto, Löwenborg, Petersson and Stenborg are archae-
ologists by training, whereas Börjesson and Huvila represent the field of infor-
mation studies. These are not the only fields represented though, as different
authors have a background and interest in various neighbouring fields from
museum and archival studies to heritage studies, as well as geographical infor-
mation science and statistics to computer and information systems science. The
volume has been written in company, but not together, to give room for different
perspectives and to retain the polyvocality of bringing different disciplinary
perspectives together. As such, it is of them all without being a work of theoretical
or empirical inquiry into archaeology, information studies research on archae-
ological information work or, for instance, an archival studies investigation of
records management in archaeology.

   As a whole, this volume ended up revolving around two major themes of
information and data and that of visual approaches. However, instead of being a
two-part volume, these two themes converge with each other and with a large
number of other themes that emerge in different contexts to be brought together
and explicated again later in the volume. Börjesson and Huvila write about the
prospects of making digital archaeological data available for future knowledge-
making. The chapter is based on the results of two interview studies of
archaeologists working in, and with, the Swedish contract archaeology sector.
Löwenborg's chapter discusses the use of big harmonised GIS data sets from a
large number of excavations in archaeological knowledge-making.

   Whereas Löwenborg's take on archaeological fieldwork is based on statistics,
the chapter of Dell'Unto focuses on fieldwork, but instead of a macro-level
perspective, it takes a micro-perspective to knowledge-making at an excavation,
and instead of statistics, it is based on a visual approach. In contrast to the long
history of claims that visual methods are useful for archaeological reasoning,
Dell'Unto digs deeper into the question and discusses how and on what premises
real-time visualisation in the field converges and benefits archaeological know-
ledge-making. Petersson, in collaboration with Larsson, continues with the
theme of visual approaches but instead of investigating it in the context of

fieldwork, their perspective is on museums and the impact of digitisation on storing and storytelling for heritage communication. Petersson draws from an extensive review of examples of the use of digital technologies for conveying archaeological information from the Nordic countries, including projects they have participated in as observers and designers. Stenborg continues a related line of inquiry in his chapter on the mediation of archaeological information. He draws from two case studies of the mediation of archaeology in two seemingly distant, but in many respects related, cases related to medieval Swedish and indigenous Brazilian artefacts and their afterlife as artefacts and digital objects.

This volume is concluded by two chapters and an epilogue. First, Huvila draws together insights from the earlier chapters of the book to outline a more systematic understanding of archaeological information work. Whereas the first of these two chapters scrutinises information, the final chapter of the book expounds on the question of the impact of the digital by outlining the *loci* of its influence on archaeological information work based on the empirical and practical findings of the authors of this volume.

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1   Digital archaeological data for future knowledge-making

Lisa Börjesson and Isto Huvila

Introduction

Acts of naming, structuring, synthesising, describing, registering and storing – in short, acts of archaeological documentation and archiving – are significantly formative for the outcomes of archaeology. A central idea in archaeological documentation, as well as in the curation of archaeological archives and collections, is that documentation is not merely for research in the present, but because of the destructive nature of most archaeological investigations, for all researchers to come. This perspective on documentation, the prospect of perpetuation – perhaps taken for granted by most archaeologists – provides a particular framing (or epistemology) for doing and caring for documentation that is not necessarily as self-evident or simple as it might seem. The idea that documentation is to be kept, made to last and used again, penetrates the documentation process from its initial steps throughout the continuum of record keeping and archiving practices. Yet, the idea of perpetuation is subject to negotiations over time. The answers to the questions: what should be documented and at which level of granularity (e.g. objects, contexts, sites), what should be kept (e.g. data, analysis, narrative), why, and for which users and (re)uses (e.g. for researchers, for antiquarian authorities, for a general public), continuously changes as new theories, methods and technologies allow for alternative imaginations of documentation use to take shape. The prospect of perpetuation is thus not one, but that of many, of different configurations of longevities.

   Looking back, the ideas from classical antiquarianism to the present-day information management and curation of collections have influenced what has been considered interesting and informative to document, and valuable and relevant for the purposes of knowledge-making. And vice versa, the choices made by practitioners responsible for documenting and archiving, and the things documented and archived, have had an impact on what has been and is possible to study, and consequently, where the interests of the users of the documentation have led (Lucas, 2012; Schnapp et al., 2013; Trigger, 2009). A striking example of how important the idea of keeping and reusing documents is in archaeology, is the trope (and realities) of the ongoing heritage sector 'curation crisis' (Dallas, 2015; Sullivan & Childs, 2003). The curation crisis (exceeding archaeology and

the challenges of keeping documentation, involving the curation of all heritage collections), would not be there were there not certain ambitions about how to keep and reuse documented heritage. These expectations are formed on the basis of both what actually can be done, but also on what can be imagined to be done with documentation, and which future uses it is possible to imagine. A matter-of-fact remark, made by Sullivan and Childs' in a 2003 (long over a decade ago!) discussion about archaeology repositories' entry into the 'computer age' provides an illustrative example of how fast we remodel our expectations on documentation:

> [R]epository staff could not have known that the Internet would permit remote access to collections.
>
> (Sullivan & Childs, 2003, p. 104)

Although computers already had been used for decades in archaeological document creation and management, the evolution of Internet use radically altered the imagination of what computer technology and digital documentation could be used for. This is but one example of how fast and fundamentally expectations on documentation change.

In this chapter, we (keeping the pace of changes in mind) delve into the state of archaeological documentation from the perspective of expectations on documentation. We provide an overview of the institutional infrastructure, and analyse policies and practices contributing to, and working for (different configurations of), longevities of archaeological documentation. The aim is to bring to the fore the expectations on documentation developing as digitisation disperses throughout archaeology. By doing so, we present a perspective on what is being done with documentation in the presence of the digital, without forefronting the digital (in contrast to taking the perspective of *digital* archiving, *digital* curation, or *digital* stewardship and so on, cf. Dallas, 2015).

Practices refers to acts of making and unmaking (Pickering, 1992) and directs our attention to what archaeologists and archivists do and do not do with digital archaeological data (comparable to earlier uses of *archaeological practices* for referring, for example, to methods for doing fieldwork). Thus, attention is directed towards the archaeologists producing and depositing materials and the archivists, rather than the perspective of the archival institution (cf. Dallas, 2015). The archaeologists and archivists act in a *field of resources*: bodily and material resources, as well as conceptual and social tools and technologies (Pickering, 1992; Talja & Nyce, 2015). Some of these are *digital*, that is, resources enabling creation, processing and use of digital information, or supporting use of digital resources, for example, policy or ideals directing and encouraging the use of certain digital resources in specific ways (Börjesson et al., 2015; cf. Braman, 2006; Hunt, 2005). Examples of the array of digital resources in archaeological practices are digital maps, e-mail, digital and digitised context sheets (for recording of finds features of sites).

As a consequence of the archaeologists' and archivists' perspective, the analysis highlights discrepancies (due to, for example, misunderstandings or disagreements) between the policy discourse, the archival institutions' discourses and the experiences of those delivering to, and working for, the archives. Analysing practices in this fashion is central for understanding how documentation becomes informative and valued as worthy (or not) to archive (cf. Frohmann, 2004), that is, for understanding what ends up in archives. In the context of research and education, descriptions of research genres (such as those generated through the analysis of documentation and archival practices) is crucial to document users' research literacies (Feinberg, 2015; Muckle, 2008), that is, for them to be able to access and assess the content of particular documents today and in the future. Additionally, teaching documentation is arguably improved by empirically based descriptions of documentation and archiving practices, in addition to so called 'best-practice' cases depicting ideal orders (e.g. ADS/Digital Antiquity Guides to Good Practice or in Sweden, the guidelines published by the National Heritage Board). From a policy perspective, insight into the discrepancies between policy and practices are crucial for policy development. Managers of archaeological documentation on national and regional (at national and regional heritage administration) and organisational levels (at archaeology departments and in contract archaeology organisations) are served by knowledge about archiving practices in their strivings to improve information infrastructures and the flow of information therein. Last, and importantly, analysis of practices is the starting point for innovations to improve documentation practices. In the discussion concluding this chapter, we place emphasis on how the analysis can inform development of policy for documentation and archiving, and development of documentation practices.

This chapter exemplifies the pertinent issues relating to the general question of archiving digital archaeological data by referring to a case study conducted under the auspices of the ARKDIS project in Sweden. Swedish archaeology, similarly to archaeology in many other countries, is undertaken both as part of academic research, teaching and in the form of contract archaeology prior to land-development. Contract archaeology organisations (government departments, public museums, foundations and commercial firms) do most investigations (Riksantikvarieämbetet, 2016; *Tillämpning av 2-4 kap. lagen* [1988, 2008]).[1] The contract archaeology is organised as a semi–regulated market. Institutions are allowed to compete on tenders. The market is, generally speaking, less regulated than in France and the Netherlands for example, but more regulated than in the UK and the US. National and regional authorities oversee and provide the infrastructure for archiving digital documentation.

The analysis in the chapter is based on policy analysis (made for the purpose of this chapter) and two interview studies. Policy documents is a central resource from a heritage management point of view as policy aims at directing documentation and archiving in archaeology. In this chapter, we analyse how policy documents frame archiving of digital archaeological data, as well as the use and non–use of digital resources in (a) archaeology practitioners' delivery of digital

documentation to archives and (b) in regimes of worth and the making of meanings in the work of archivists. The two interview studies are one about contract archaeologists' every-day document practices, including archiving (Börjesson, 2016), and one concerning the experiences and meaning-making of professionals working with the archiving of archaeology (Huvila, 2016a). The former empirical work covers six interviews with contract archaeologists working in commercial firms (ranging in size from only a few to around 20 employees). The latter includes 14 interviewees from stakeholders in archaeological archiving ranging from the national heritage administration to regional actors and small contractors with a handful of employees. The analysis draws on policy and practices in Sweden, but by using literature on archiving of digital documentation to discuss the results, we make suggestions for how the findings can inform policy development, as well as the development of documentation practices elsewhere.

On making digital archaeology documentation last

In the following we provide an overview of archival institutions and standards in archaeology and cultural heritage, and on major trends in digital archiving. In addition to the theoretical and practical developments within archaeology (as illustrated in the Introduction), archival policies are also shaped by ideologies and discourses external to the discipline. One of the most influential discourses during the past decade draws on ideas of openness and has been lobbied for, and longed for, both by actors in the research community (e.g. Peters & Roberts, 2012) and in society at large (cf. to the parallel open government discourse advocating citizen access to government data). Open access to research data and publications is framed as an ideal and mandated by institutions on transnational (e.g. European Union, European Commission, 2012) and national levels (e.g. the US National Science Foundation, National Science Foundation, 2015); the UK Department for Business Innovation and Skills (House of Commons, Department for Business Innovation and Skills, 2012); and the Swedish Research Council (Vetenskapsrådet, 2015). Traces of the openness movement and other extra-archaeological discourses and research policies blend in archaeological theorising (e.g. Kristiansen, 2014), organisation and institutionalisation of the discipline (e.g. the work of European Archaeologiae Consilium and European Association of Archaeologists, ARCHES-project), writing of guidebooks and best practices (e.g. ADS/Digital Antiquity Guides to Good Practice, or in Sweden, the guidelines published by the National Heritage Board) and in the everyday practices of how archaeology is conducted, documented and archived.

The development of policies and infrastructures for archiving digital archaeology documentation has been supported by a variety of organisations (such as archaeology professional associations, archival institution associations and heritage society associations), but largely driven by a relatively small number of pioneering actors. These forerunners, such as the national trusted disciplinary

repositories, the UK Archaeology Data Service (ADS), the US Digital Antiquity (maintaining the Digital Archaeological Record, tDAR, repository) and OpenContext, have gained prominence both in their national contexts and in the international discussion. Even some of the general data repositories, perhaps most prominently the Dutch Data Archiving and Networked Services (DANS), have been playing a central role in developing the practices of managing digital archaeological documentation. These forerunners are not mere repositories in a traditional sense, but have, with different methods, expanded the role by aggregating, promoting and distributing digital data and publications in the spirit of 'open archaeology'.

These general digital archives, disciplinary specific repositories and organisations tailored to more specific tasks (e.g. specifically archiving research data) have joined forces in a number of influential projects such as ARIADNE (integrating archaeological data infrastructures) and ARCHES (developing an open source data management platform for the heritage field). The major repository institutions and facilitating projects exercise their influence by developing technologies and services for the stewardship and curation of data, by evaluating the progress of their own work and by publishing literature on the experience of the institution from a systems perspective (e.g. Kansa & Kansa, 2013a, 2013b; Kintigh & Altschul, 2010; Moore & Richards, 2015). The motivation, as summarised by Kansa and Kansa is that 'The growth of new, data-intensive research methods will lead to increased pressure for open access and open data' (Kansa & Kansa, 2013a, p. 103). They argue that archaeologists need to take on a more professional attitude towards working with data, including familiarity with data curation and preservation requirements. Kansa and Kansa further suggest data publication, similar to the established processes of publishing scientific texts, as a solution to poor archiving of archaeology data (both to solve the problem of non-archiving and to counter archiving with insufficient metadata). By this suggestion, they argue, OpenContext (the organisation Kansa and Kansa represent) takes data stewardship one step further than archiving institutions like ADS and tDAR (Kansa & Kansa, 2013b). In sum, it is evident that while many of the larger (and nationally influential) institutions collaborate internationally, the situations to which each archive tailors its procedures – and the views on how to ameliorate archiving – differs significantly between the institutions.

Looking at this landscape from a policy perspective, archival policies work on two levels: nationally, to align the activities of government departments, disparate actors conducting research and industry, and internationally, to align different national policies and enable international use of data. On a local level, the policy landscape is convoluted further by the existence of more or less explicit policies on, for example, disciplinary, regional and institutional (e.g. university) contexts. On a more practical level, we see discussions of more practical issues related to archiving digital documentation, such as knowledge organisation systems (e.g. Tudhope et al., 2011), document formats

(e.g. Evans & Moore, 2014) and emulation and migration between formats (e.g. Papageorgiou, 2015). Another, but substantially smaller, set of literature contains a wider discussion of archaeologists' actual documentation and archiving practices and how these practices might affect archaeological knowledge-making (Huggett, 2015). In a discussion of the relation between data and knowledge, Jeremy Huggett argues that 'data ... emerge only as a consequence of knowledge and information; in other words, data come into existence in the first place through human engagement' (2015, p. 18).

Information and archival policies in Swedish archaeology

The following analysis leans on one national example and should be read as such. The purpose is to illustrate how expectations on documentation evolve in heritage policy and in the practices of archaeologists and archivists. In Sweden, a number of policy documents, from the general national heritage conservation legislation to the detailed National Heritage Board's directives for electronic documents, regulate archaeological documentation and archiving. Here, we analyse the content of two of these, central to creation and archiving of documentation in contract archaeology: 'Guidelines for the implementation of the heritage preservation legislation: Contract archaeology: Reporting, dissemination and archaeological documentation material' (Riksantikvarieämbetet, 2015), and an attachment to the aforementioned: 'Archiving of archaeological documentation' (Riksantikvarieämbetet, 2012a). In the following, we highlight one central principle in these policy documents: archivability, and one central change between the earlier and the current policy for archiving: the change from encouraging to mandating archiving of digital reports.

Archivability: a threshold for documentation methods and technologies

A central message in the policies for archaeological documentation is that documentation should be made accessible for government agencies, researchers and the public (Riksantikvarieämbetet, 2012a, 2015). Therefore, archaeological documentation materials (sorting under the Swedish Public Access to Information and Secrecy Act [SFS 2009:400; Riksdagsförvaltningen, 2009] and the Archives Act [1990:782; Riksdagsförvaltningen, 1990]) should be archived in public archives and be made accessible to users. Accessibility should be ensured both by means of traditional archiving of physical paper documents, but also by digital archiving and dissemination of reports and documentation materials through websites (e.g. the websites of the National Heritage Board and the County Administrative Board) (Riksantikvarieämbetet, 2012a). From 2015, all reports and documentation materials should have a CC BY licence, enabling others to distribute, remix, change and build upon the material, as long as they give appropriate credit to the original licensor (Riksantikvarieämbetet, 2015).

The guidelines for reporting (Riksantikvarieämbetet, 2015) also emphasise the importance of scientific work methods. In the guidelines, contract archaeology investigations are equalled to research investigations, and as a consequence:

> [T]he same demands that are put on the publication of university research results shall be put of the presentation of results from the [contract archaeology] investigations.
>
> (Our translation, Riksantikvarieämbetet, 2015, p. 9)

And further, that good scientific quality contributes to the following:

> [K]nowledge development, or to do the unexpected, pose new questions or *to use new methods*.
>
> (Our translation and italics, Riksantikvarieämbetet, 2015, p. 10)

The guidelines also acknowledge that the most central part of the documentation from an investigation often is the (de facto often digital) database containing measurement data, relations, context sheets and finds registrations (Riksantikvarieämbetet, 2015).

At the very same time, the policy, and especially the document 'Archiving of archaeological documentation' (Riksantikvarieämbetet, 2012a), places responsibility on the investigators, the County Administrative Boards, and on the archives, to ensure that documentation is created with methods and materials that facilitate preservation. The investigating archaeologist is responsible for creating and organising documentation materials in such a way that it can be preserved. The County Administrative Board is responsible for communicating their demands on the documentation material and to ensure that the designated archival institution can accept the documentation in the format they request. The archive is responsible for guaranteeing that archived materials are accounted for, curated and stored appropriately.

The appendix states further that the allowed deposition formats (analogue or digital) are specific to the archival institution designated to preserve the documentation material from a particular excavation. These vary considerably between different national and regional repositories:

> The investigator should, already at the creation of documents (reports and other documents), use mediums, materials and methods supporting preservation and adapted to delivery to the receiving archive. *Is it possible to deliver documentation digitally, and if so, does the receiving archive make requirements regarding format etc.?*
>
> (Our translation and italics, Riksantikvarieämbetet, 2012a, p. 5)

The requirements to use scientific (scholarly) methods and the parallel encouragement to use new methods are expressed in a context where the archivability of each documentation material (differing between the counties) is the paramount threshold for which methods archaeologists ultimately should choose and which materials should be produced during contract archaeology investigations. Even if archivability thresholds are formulated reactively, as a response to technical advancements, and with the purpose of mitigating risks to lose fragile digital materials, archivability thresholds do, as time passes, soon become prescriptive. Thus, archivability is a central principle in information policy for archaeological archiving, potentially also affecting documentation methods (both those branded as scientific and those viewed as new) and the documentation created.

Extended guidelines, mandating archiving of digital reports

A central change between the earlier and the current policy for archiving in Swedish archaeology is the change from encouraging to mandating archiving of digital reports. Until 2015, the previous guidelines for implementation of the Heritage Conservation Act (Riksantikvarieämbetet, 2012b) encouraged the investigating organisations' making and self-archiving of PDF files:

> Use of the Internet for publication should always be a complement to the paper reports sent to archives and libraries. Reports and articles can advantageously be provided on the investigating organisations' web sites. However, it is important that the quality of the pdfs are good, especially when it comes to maps and images.
>
> (Our translation, Riksantikvarieämbetet, 2012b, p. 105)

Yet, the guidelines did not provide criteria for good PDF quality. For further details, the guidelines direct the reader to the appendix on archiving of archaeological documentation (Riksantikvarieämbetet, 2012a). The appendix makes suggestions regarding formats and standards for particular types of analogue and digital documentation (measurement data, drawings and images), requires establishment of a strategy for storage and curation of digital documents at the archives and refers to yet another set of information policy documents: the regulations for electronic (synonymous with digital) documents and the separate guidelines for technical specifications for electronic documents, both issued by the National Heritage Board. Yet, for specific requirements for each set of documents and data to be delivered, the appendix refers to the different national and regional archives local guidelines (which can differ, see section about archivability) (Riksantikvarieämbetet, 2012a).

The reworked guidelines for implementation of the heritage conservation act (Riksantikvarieämbetet, 2015) mandates (as opposed to encourages)

production and delivery of PDF versions of the documents basic report, scientific adaptation, popular summary and popular publication to SAMLA, the open archive of the National Heritage Board (opened to users outside the National Heritage Board in 2013) (Riksantikvarieämbetet, 2015). The guidelines regarding the aim of reporting, report content and content quality, distribution, publication, dissemination and storage are significantly extended, from four pages (in 2012) to 22 pages (in 2015). The section on required content in basic reports is notably extended (to six pages in 2015) and is more detailed in comparison to the previous version. However, with regards to the digital form of the report documents, the guidelines still rest on the formulation:

> It is important that the quality of the pdf is good, especially when it comes to maps and images.
>
> (Our translation, Riksantikvarieämbetet, 2015, p. 13)

The guidelines reference the 2012 appendix about archiving of archaeological documentation (Riksantikvarieämbetet, 2012a). Thus, from a policy perspective, the major change in the digital documentation expected to be conducted is the change from encouraging digital archiving of reports, to requiring practitioners to archive digital reports. For archaeological documentation (other than the report documents), the situation is still dependent on the archivability of each type of documentation material.

Delivery to archives

Turning the perspective from policy to practices, the double standard (analogue and digital documentation), has resulted in an array of practices for delivering documentation material to archives. In a qualitative interview study of documentation practices in contract archaeology (Börjesson, 2016), conducted a few months after the introduction of the updated guidelines for documentation, six archaeologists accounted for a variety of ways of delivering born-digital documentation to archives: archiving of born-digital material printed on paper; rounding up digital documents from several undertakings and delivering occasionally; and delivering digital documents together with analogue documentation for each undertaking. While archiving practices could benefit from being analysed in greater detail with respect to type of undertaking and type of material produced, this analysis gives an overview of issues pertinent to the informants interviewed.

Digital documentation delivered in analogue formats, or not at all

Eva, an archaeologist at a smaller contract archaeology firm explains how she, after consulting both the County Administrative Board and the National

Heritage Board, concludes that printing is the solution for delivering digital materials to the archive in the region where she works:

EVA: We have to deliver reports, but today almost nobody draws [by hand], but does everything digitally. And we asked the County Administrative Board: what should we do with all the background material? 'Ehh, we don't know' [answered the County Administrative Board]. Where are we to deliver it [the digital drawings]? Because, what will be in the archives in the future is our little report. Ok, and that [the report] cannot be in very high-resolution, or it is a paper version. But, if someone wants to access that drawing in a larger scale, what are they to do? No answer [from the County Administrative Board]. And then I asked the County Administrative Board to ask the National Heritage Board, because we want to know [what to do with digital drawings]. And then NN [from the National Heritage Board] answered, that, we [the investigator] do not have any responsibility to keep the [digital] material. That leaves me baffled. And then: 'you'll have to print paper copies and attach'. Ok. So we answered the County Administrative Board, we'll print [digital drawings], in A3, a bit larger, and staple to the report. [. . .] That, that's a giant gap. [. . .] We have not delivered any [digital] documentation material to the archives (Eva, 00:57:30).[2]

Eva contacts the County Administrative Board, and urges them to contact the National Heritage Board, in order to find a solution to the discrepancy between how she would like to archive her digital drawings, and the form of documentation the archive can receive. Yet, due to the variation between Eva's resources for creating drawings, and imagining reuses of drawings, and the archive's resources for keeping drawings, the response, ruling in favour of the archive, is disappointing for Eva.

Digital images can be at least transferred to an analogue medium (as paper), although at the cost of loss of resolution and interactivity. However, Eva gives yet another example of digital documentation that her organisation creates, and would like to archive, but that the archive cannot receive:

EVA: We have started with 'sustainable archaeology'. I'm going to give you an example. In county X, 1500 skeletons from age X have been excavated. Do we need to excavate more, before we've analysed all of these? I don't think so. [. . .] The museums don't want any more artefacts. Ok, we can investigate if it [an object] is scientifically [relevant], we can re-deposit if it [the object] is not needed because it's exceptional, but it's traditional [. . .] We have started to 3D scan objects. [. . .] we have the methods to digitise a lot, but who the hell takes care of 3D files? The National Heritage Board should do that. And I hope by God that they figure this out (Eva, 01:00:43).

In this case, with the 3D scanning of objects, it is more evident how the choice of documentation method is connected to the theoretical ('sustainable archaeology')

development of archaeology. Eva expresses a resistance to the prevailing methods for investigating and documenting objects (in this case human remains) and suggests a different investigation and documentation method (3D scanning). However, the theoretical and practical development of 3D data rendering methods are stalled by the fact that public archives currently do not accept 3D data. Yet Eva, and possibly also archaeologists in other organisations, experiment with this method and the 3D documentation materials are likely to be found in many contract archaeology organisations' corporate archives.

Parallel digital and analogue archiving, with exceptions

John, in contrast to Eva, works in a region where archives accept digital documents. John works in a sole proprietorship and has chosen to round up digital documents from several undertakings and deliver occasionally:

INTERVIEWER: What do you do with the documentation material that does not become part of the report?

JOHN: I deposit it [to the archive]. I print everything on archival paper, one-sided, [with an] approved printer, I am meticulous. I don't print images. Those I deliver digitally. I usually drive over to the archive with a USB stick, because they do not want it on a CD. And they prefer it that way [on a USB stick], and transfer it [to their digital archive], like once a year (John, 00:48:15).

John does not talk about an overt negotiation with the authorities about how to archive digital material, but communicates instead with the archival personnel in person, as he drives over to the archive to deliver the USB stick containing digital documentation once a year. This habit stands in contrast to how Erik, a practitioner in a larger contract archaeology organisation, carries out his delivery of archival material:

ERIK: When I'm done with one [investigation], and when the report is produced and done, then I print everything on archival paper, and make sure that everything that has to do with documentation, and, even a selection of e-mails, and some analysis reports and those kinds of things, [I] print all that on archival paper. And then I bring all the original drawings from the field work and that goes in too. And sometimes I even add note books used during fieldwork. All of this I archive in City X. [. . .] Or, when I dig in City Y, then it goes to archive in City Z.[3]

INTERVIEWER: And what do you do with the Intrasis [Intrasite Information System, a proprietary geographical information system used for documentation of archaeological fieldwork] databases?

ERIK: It's part of, it's part of the archival material.

INTERVIEWER: But how do you, technically, archive those [Intrasis databases] today?

ERIK: Those are archived digitally, we have a digital archive . . . we copy a lot of info to a CD: Intrasis project, all of these things that I have printed, I give

those digitally too, from the report of analysis results from C–14 labs and like, everything. All of that I put on a CD, and then they [the archive] puts it on their server. That's how it works (Erik, 01:04:05).

Erik, in contrast to John, delivers digital documentation to archives after each undertaking. Both John and Erik initially say that they print 'everything' for analogue delivery, but then correct themselves. John does not print the digital images (beyond those used in the report), and Erik delivers the Intrasis database digitally. Hence, we can expect to find overlaps between analogue and digital materials for each investigation, but also a selection of material delivered only digitally.

In addition to the previously described variation between the analogue and digital sets of documentation archived for each single investigation, there is a simultaneous variation in how much of the documentation created during each investigation that goes into the codex-like report document, and the amount archived as ancillary documentation material. Practitioners' ideals regarding how much documentation material should be fitted into a report range from those advocating extensive report documents, with as much documentation material as possible included, to preferring as brief report documents as possible, with the lion's share of the documentation materials archived as ancillary materials (Börjesson, 2016).

Yet another aspect shaping the documentation (reports and ancillary materials) that users encounter in the archives is local standards employed by some (mainly larger) contract archaeology organisations.[4] The archaeologist Sven explains in the following text how they create field documentation according to a local standard:

SVEN: We have been working two-three seasons with digital context sheets. And that's something coming in several organisations. So, all the written documentation [...] we try to do digitally, in-field. We have tablets, and [...] forms that you fill in with checkboxes and textboxes, and you can even make sketches. Then we can transfer that [documentation] straight into the data system.
INTERVIEWER: Have you [your organisation] created the context sheets?
SVEN: Yes, we have. And they're designed to fit the data management system that we have (Sven, 00:18:42).

It is difficult to say today how much locally developed micro-systems for data creation and management, like the one Sven explains, will affect the state of the documentation archived in public archives. However, it is reasonable to posit that future users of archaeological documentation can benefit from the insight into the diverse documentation and data creation practices (analogue/digital, extensive/brief, following nationwide standard/shaped by local solutions), and the variety of ideas of documentation quality driving each of these practices, in order to understand the variety in the archived archaeological documentation materials.

Local, unofficial archives – parallel infrastructures for knowledge management

Besides delivering digital documentation to official archives, the informants in the interview study talk about their own organisations' digital archives. Eva keeps digital materials as they are not accepted by the archive in the region where she works:

EVA: We keep all [digital] material, of course, we keep everything in different folders, for different undertakings. But, like NN [at the National Heritage Board] said, we don't have to. But it makes me frustrated. I want to keep it [the digital drawings], but I want it to be accessible. I think it is very dissatisfying (Eva, 00:59:58).

Erik does, like Eva, keep digital documentation materials. However, Erik does, contrastingly to Eva, not account for any particular reason to keep documentation material archived and (ideally) accessible through public archives:

ERIK: And we do also have a digital archive. We don't keep the original drawings and that kind of material, those we deposit [at an archive], but we have a digital archive with our projects (Erik, 01:06:10).

John however, talks about a personal experience motivating his company in keeping digital records:

INTERVIEWER: Do you keep documents here [at the organisation's office] too?
JOHN: Yes, everything I deliver I keep as well.
INTERVIEWER: Why do you keep [documentation materials]?
JOHN: It's an obsession! I keep all sorts of things. I cannot throw away. It can be good to have. And then, I know, it happens sometimes, you throw away – it happened just recently that an old project was re-opened in City X, that I had written the investigation plan for 'hundreds of years ago', and then I had thrown that away, for some weird reason. And they [the County Administrative Board] wanted to see the investigation plan, and now they found it. I gave them clues for where to look. [. . .]
INTERVIEWER: So, people looking for material sometimes contact you?
JOHN: The County Administrative Board, they contact me, because they know that I have worked for so long in City X. It happens that they call me, and I help them with some information on where to find documents (John, 00:49:37).

The investigating companies keeping digital documentation thus form a parallel, informal archival infrastructure. According to a recent survey conducted by the National Heritage Board (Törnqvist, 2015), this infrastructure has been working surprisingly well, and apparently, very little data has been lost so far. Gustav, a representative for a national archaeological heritage institution, confessed that he

and his colleagues, 'not seldom', visited archaeology companies' websites while seeking information they have or at least should have in the official archives. Company archives can compensate for a lack of formal digital archiving (as in Eva's region), but do not lose their value when digital documentation is archived in formal public archives. Despite being contractors on the archaeology market, with no obligation to keep and manage digital records after each investigation, Erik and John still find it natural to keep digital documentation. John has personal experience of the value of his record keeping for the benefit of the regional heritage administration, as the County Administrative Board personnel call him from time to time, to learn where to find certain documentation. At the same time, however, for instance, Kerstin, a coordinator at a private archaeology consultancy, remarked that this voluntary keeping of digital data costs her company money and the cost is difficult to justify from an economic perspective.

In addition to the local, corporate field documentation archives (discussed previously), the interviewed informants talk about further local datasets, not to be found in any official archives, but still playing central roles in their daily work. Eva talks about two unofficial datasets she consults regularly: first, a set of data (not yet digitised), compiled by her organisation, of all the excavated sites in the region where Eva's organisation works. The second dataset is an Excel spreadsheet of all the sites where someone (an archaeologist, a landowner, the public, etc.) has reported a possible find/site, which has not yet been investigated. This dataset is created and managed by the County Administrative Board, and the investigating organisations have been given access to aid their desk-based assessments and in-field surveys (Eva). There is no data on how many of this type of datasets there are. Notwithstanding, the analysis validates that these type of data sets are central to contract archaeological prognostics and decision making at early stages in investigation processes. As they are not finished or closed but 'working' documents, they are not archived and searchable in official archives, but only accessible through informal, personal contacts.

Documents and data from archivists' points of view

The interviews with archivists confirm to a large extent the general picture of how archiving of archaeological documents and data functions in Sweden. Practices vary between individual archives and in spite of the relative pro-liferation of international guidelines and standards, there are no generally approved practical procedures at the local archives represented in the interview study on how to manage digital materials. The informants were notably unanimous that the existing standards tend to be too general, they do not make sense in the local context and they can be too difficult to implement in practice. In addition, because the legislation that dictates the appropriate management procedures is national, the guidelines should also be national and on par with the current legislation. From archivists' perspective, the major problem is the lack of guidelines of how to manage digital material, lack of clear requirements to the deposited materials and the absence of a technical system to manage

digital assets. There is also no clarity in how the responsibilities to curate digital materials are distributed between IT departments and archives. The general tendency to side-track archivists in digital information management also applies to archaeology. In addition, the difficulties of navigating the often-conflicting expectations and priorities of archival work becomes accentuated when working with digital data.

Even if a part of these issues can be traced back to technical issues with the digital data and lack of clear guidelines (Huvila, 2016b), it is equally apparent that the established practices of working with analogue data complicate the situation. Both Kristina and Jonas agree that their focus has been on the management of administrative records, whereas the archaeological documentation data has been mostly accepted and deposited as field directors have submitted it, without going through, appraising and describing the material, or asking for the field directors to submit missing documentation. Also, the current regulations for managing digital archival data do not allow a similar approach to managing records and would require laborious processing and conversion of all archival data and the use of specific archival document formats. In this context, the main issue that hinders the archiving of digital versions of written investigation reports is that the speed of deploying digital records management systems in the public sector in Sweden has been slow, whereas the management of other types of digital information is slowed down by more profound conceptual issues such as the purposes and relevance of documenting and keeping particular pieces of information discussed in this volume by Löwenborg and Dell'Unto.

A major impeding factor is that 'data' is a difficult artefact from the archival perspective (Huvila, 2016a). Within the archival profession, there is a long tradition of managing formal administrative documents both in theory and practice. From this perspective, an investigation report is a relatively non-problematic artefact whereas the often unspecific and heterogeneous data is more difficult to manage using a similar approach. Åsa notes that 'the data we acquire, it is difficult to archive in a way so that it will be possible to utilise it in the future, or use directly, if you don't [. . .] clean it and structure it'. In addition, in order to do that, as Carl underlines, different types of data should be archived in dedicated systems developed for the particular types of material. The passages show that the challenge is both technical and conceptual. Data is practically always lacking cues on the procedures, premises and conditions of the original investigation, whereas a report is both from a writer's and reader's perspective, a more self-contained entity.

A parallel issue to the practical problems of working with the data is that the introduction of digital data in the archival context has both direct and indirect impact on archival work and its priorities. The digitisation of the information work of the stakeholders of archaeological information means that there are new information needs, information is requested in new forms and formats, and to a certain extent, by new actors. Åsa explains about new types of analyses she can conduct using digital datasets. Citizens are seen as a significant stakeholder and user group by multiple informants. As Carl hopes, in the future it will be much

easier for citizens to access digital datasets: 'Currently [...] We are working on how to reach out broader than we do now. You have to be quite knowledgeable to be able to access information in the archives [today] [...] And you have to physically visit an [organisation] to be able to access the information'. Navigating these demands and the inherently conflicting demands of archival work (Huvila, 2015) to preserve archival records, serve the organisations producing them, curate cultural heritage and to serve other stakeholders in the society change when digital technologies introduce new possibilities to work with information, new challenges relating, for instance, to the increasing amount and heterogeneity of information, and new assumptions of how information should be immediately and openly available online. Digital practices can also bridge different perspectives to the priorities and perceived worth of archives and archival work (Huvila, 2015) and provide new means to manage the conflict between keeping information safe and making it available through digital copies.

Making documentation last in a transitory space – a concluding discussion

The analysis of policy and archiving practices in this chapter primarily reflects the national context of Sweden, and primarily the situation in contract archaeology, but serves as point of departure for a wider discussion of what a discipline like archaeology makes, for its purposes, of digitisation and open access. The phraseology of the archival policy texts relating to the use of digital formats has shifted from encouragements to requirements. At the same time, the requirements on delivery of analogue formats have not decreased but remain constant. Also, ideas growing as a result of digital affordances like demands for open access licensing (CC BY), become equally effective for analogue and digital formats (although digital does not in and of itself equal open access). As the situation is shaped by expectations on making and keeping both analogue and digital documentation concepts fore-fronting the *digital* (e.g. *digital* archiving, *digital* curation, *digital* stewardship) create an insufficient picture of what is going on.

When looking beyond and wider than the 'digital' we can conclude that the policy harbours a striking tension (although perhaps an unavoidable one) between encouraging archaeologists to use new methods, and to create and organise documentation material in such a state that it can be preserved (in a designated archive). We call this *archivability* and argue the archivability of documentation material (and the preceding documentation method) constitutes a pivotal threshold for documentation in archaeology. A major issue is that archaeologists' resources and methodological imagination to create documentation is by far exceeding what the archival institutions are capable of accepting. At the same time, the archaeologists in this study are keen on inquiring into the delivery options for the official archives and to determine the best delivery method possible. However, the *de facto* delivery method is a combination of which format(s) the archive demands (and can receive), and the way in which the archaeologist finds to be reasonable to deliver these format(s). Following from

these premises, the transfer of digital datasets into analogue formats is a key activity (and the transferability of digital documentation to analogue formats), and archaeologists' ability to perform this transfer is a key competency in the delivery practice. Also, the importance of unofficial local 'working' archives brings our attention to the significance of unfinished records and the absence of these in the official archives.

From archivists' point of view, archiving suffers from a lack of (and sometimes lack of consistency between) guidelines (even if the guidelines today are much more extensive than before as we have discussed before), generally approved procedures and technical systems to manage digital assets. The problem is that even if new guidelines, procedures and systems are developed, it is difficult to match the growth of new technologies and proliferation of uses of archaeological information. New stakeholder groups come with new demands on the archived information. Instead of being content with administrative records or summary reports, the most relevant information might be found in the currently often poorly accessible excavation data. Thus, from an archivist's perspective, it is not a question of mirroring an analogue practice to digital, but to maintain an analogue practice while at the same time inventing and implementing guidelines, procedures and systems for digital assets.

Based on the analysis presented above, we posit that archiving of archaeological documentation takes place in a transitory space, characterised by movements in not one, but multiple directions. Rather than talking about a crisis (like the curation crisis, to overcome) we argue it would be beneficial to theorise the transitory space as a state for archaeologists and archivists to cope with. In this state, archiving policy expands, and its reach is fortified by ideals from the open access movement. At the same time, as new documentation methods develop, the *archivability of documents* remains a significant threshold for ingestion into the archives. In situations of delivery, *the transferability of information back and forth between analogue and digital document formats* is a central filter for which information gets represented in the archives. However, local and unofficial working archives, containing unfinished documents and data-files, harbours significant information never reaching the official archives. Archivists experience new demands, both on the archive as a memory institution, and on its organisation of work and services. The archival institutions need to *partially transcend* into new type of institutions, adopting a new relationship to the documents. In this transitory space, the digital is not the phenomena presenting the new tasks, but it is the persistence of the analogue, and the parallel and amalgamated analogue and digital documentation practices that present the real challenges.

These results have a number of important implications for archiving policy, the archival institutions and their personnel and archaeologists' archiving practices:

- First, there is a need to acknowledge that practitioners today work with both analogue and digital documentation technologies parallel and simultaneously to serve different documentation, analysis and practical purposes. As a consequence, there is a need for transferability of information between

analogue and digital formats, as well as a need to value acts of transfer as an area of expertise (how to transfer information content between analogue and digital formats in the best way for various purposes?). Further, the combination and amalgamation of analogue and digital technologies for documentation needs to be theorised as the current baseline, and further explored in research of archaeological practices and archiving.

- Second, archivability thresholds need to be established with sensitivity to the research activities each archive serves in the present. While digital technologies, even further than analogue technologies, stimulates imaginations of longevities of data and possible (often not yet fully articulated) data uses in far futures and remote, marginal and unarticulated contemporary contexts, these imaginations risk overshadowing researchers' more immediate (and perhaps more realistic) preferences. For archivability thresholds suited to the making of knowledge in on-going science, we need to acknowledge that some data should be lost and sustain a proactive discussion about how to select what should be preserved.

- Third, the value of the unfinished documents in local and unofficial archives must be appraised and granted space in archives open to the archaeology community. However, unfinished documents also need metadata (created and paid for). In order for this to be achieved, one solution would be that the role of central archival institutions change (or expand) from the repository role to a (research library inspired) service-oriented role (led by the aim to make the most relevant information accessible to the researchers in need thereof).

- Fourth, archival institutions must be granted leeway to develop the new role of 'archival institution' according to its community of stakeholders, not antedated by assumptions about these stakeholders expressed in policies.

- Fifth, and perhaps most importantly as it affects archaeological documentation and knowledge-making across the board, we cannot keep expanding the demands (set out in policies as a result of cultural heritage politics and in corresponding requirements established by archival institutions) on what should be archived and how. Devising selection and retention policies, and keeping these under constant review, is an imperative (which archives constantly work with, but that we argue should be raised as a topic for discussion in the archaeological community at large, and in particular, in the communities developing new documentation methods).

Ever-expanding demands on what and how to archive, especially if coupled with open access, is often portrayed both as unavoidable (Kansa & Kansa, 2013a, p. 103) *and* as a cure-all (Kintigh & Altschul, 2010) for any archive related problems. Although connected with considerable start-up and long-term costs, the idea is that if only state and research institutions go all-in, setting up well-functioning financial models, open access will work and solve information access and reuse problems. Digital technologies provide the imaginative affordances to come up with this idea, and to some extent, the technical resources for the building of archival structures. The structural perspective and archival policies

makes claims on practitioners and allows us to assume practitioners follow these claims. However, this study illustrates how the archiving archivists' practices work quite differently. Digital technologies facilitate the imagination and creation of information infrastructures, but at each fork in the road in the infrastructure, human engagement is needed for decision making (Huggett, 2015).

From this perspective, the future of archiving becomes an issue of how to manage the human resources needed to make the information infrastructures work. We mean not to reject the onerous work of all the trusted repositories leading important development for archiving of digital documentation, but with respect to the resources available in archaeology today and in a foreseeable future, we deem it necessary to raise the question of the state of the abilities to select and deselect in the array of forms of documentation, both among individual archaeologists and archivists, and in the discipline as a whole. We call for a revitalisation of the theoretical foundations (based on disciplinary specific principled aims and purposes, for example, cf. Löwenborg's discussion on harmonisation in this volume) and practical applications of documentation appraisal and deaccession in the context of archiving archaeological documentation.[5]

One option, put forth as a practical extension of the 'data professionalism' Kansa and Kansa call for, is the practice of 'data publication' developed from the premises of the current practices of publishing of research papers (Kansa & Kansa, 2013b).[6] Kansa and Kansa do not suggest, but we read into their suggestion, that publishing data will result in a greater selectivity in what to archive and how to archive data. This is one option, but considering the relative complexity and labour-intensity of (current) scholarly publishing practices, data publication is unlikely to be a viable option for the bulk of contemporary archaeological undertakings (cf. the statistics discussed earlier in this text). Yet another aspect impeding data publication is that a majority of all archaeological undertakings (the contract archaeology portion) need to present not only data but evaluations of the investigated areas, that is, knowledge on which to base land development decisions (Börjesson, 2017). Thus, for the making not only of data, but of information and knowledge in the process of archiving archaeological documentation, the most important challenge for archaeologists, digital humanities scholars, documentation software developers, data managers and archivists is to identify, invent and articulate options to large scale, all-embracing data archiving ambitions.

Notes

1 There are no up-to-date statistics, but based on the most recent numbers (Riksantikvarieämbetet, 2008, 2016) research investigations make up approximately 6% of the total number of Swedish archaeological investigations yearly, 4% are investigations initiated as a result of environmental deterioration (e.g. storm damages) and the remaining 90% are contract archaeology investigations. This situation is comparable to that of, for example, the US (United States Department of Labor, Bureau of Labor Statistics, 2015) and the UK (Aitchinson & Rocks-Macqueen, 2013).
2 This, and the following quotes in this section, are translated from Swedish and adapted for the written language. The interviewees have given written consent to participate in

the interviews. All names are fictitious. Places and other details with potential to give away the informants' identities are anonymised.

3 Based on rules for finds distribution, finds are deposited at different institutions. Larger cities (like City X) have their own repositories. Finds from smaller cities are stored up at a designated institution (like with the example of material from City Y going to City Z). The general rule is that documentation materials should be stored together with physical finds.

4 Compare another example of a locally developed system: 'Instant field documentation system and availability' (www.kalmarlansmuseum.se/arkeologi/ida/), as well as the National Heritage Boards' initiative, 'Registration at the source' (Swe. 'Registrering vid källan') with similar goals as the local initiatives (www.k-blogg.se/2016/04/25/registrering-vid-kallan/).

5 Although outside the scope of this chapter, the question: who pays? hovers in the background. The economics of cultural heritage is a pivotal aspect that should be brought into this discussion (as well as into the education of archaeologists and archivists).

6 A problem with drawing an analogy between publishing data and scientific texts (Kansa & Kansa, 2013b, p. 92) is that textual scientific communication (for instance the publishing of research papers) is by and large a process of social negotiation between author(s), editor(s) and reviewer(s). The terminus is not perfection from any one point of view, but a compromise between preferences. Data publication differs in the sense that, in order to 'read' and dispute a dataset, a reviewer would need to invest extensive engagement with the data, well beyond what is customary in regular peer-review practices.

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By Lisa Börjesson

- Eva (Informant 3/6), project manager in firm with less than five employees. Duration: 01:30:02. Date: September 21, 2015.
- Erik (Informant 4/6), project manager in firm with more than ten employees. Duration: 01:35:53. Date: September 22, 2015.
- John (Informant 5/6), project manager in firm with less than five employees. Duration: 01:18:59. Date: September 23, 2015.
- Sven (Informant 1/6), Project manager in firm with more than ten employees. Duration: 01:28:29. Date: September 14, 2015.

By Isto Huvila

- Kristina (Informant 1/16), archivist at a national institution. Duration 53:41. Date: January 10, 2014.
- Jonas (Informant 2/16), archivist at a national institution. Duration 50:28. Date: January 27, 2014.
- Åsa (Informant 3/16), researcher in archaeology at a Swedish university. Duration: 47:30. Date: October 21, 2013.
- Carl (Informant 4/16), administrative director of a contract financed archaeological department a regional museum. Duration: 40:00. Date: December 11, 2013.

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2 Knowledge production with data from archaeological excavations

Daniel Löwenborg

Introduction

The immense number of excavations carried out every year around the world produces new information about historic events or at least atomic pieces of evidence that can be connected to historic events through research and interpretation. Some finds are spectacular, most are relatively unremarkable and some potential sites prove to be empty upon investigation.

Now and again, sensational finds turn up in archaeologist trenches, to the great surprise and joy of those who happen to stumble upon something nearly or actually unique. These more or less random events can get widespread, in some cases global media attention, like the presumed 'dildo' found at a stone age excavation site in Motala, Sweden in 2010, a find that was cited in the news press around the world (Hedman & Hellas, 2011, pp. 20–21).

Most excavations, nevertheless, do not produce results that would make it to any headline. They are prosaic and they seldom retain the interest of the involved archaeologists longer than it takes to have an adequate investigation report written and sent off to local or regional administrative authorities and archives. In this site–centred perspective, much of the work that goes into the excavation and documentation of archaeological sites produces meagre results, such as a tiny note on a small number of scattered post holes or a lonely hearth. Results of this kind rarely reach any broader audiences, nor are they included in research studies or syntheses that would increase our collective understanding of history. Reports tend to end up collecting dust in archives, or their modern equivalent, occupying storage space on servers. Must these results fall into oblivion as meaningless and uninteresting?

If this is the case with most *run-of-the-dig* results, that is, everyday non–spectacular excavations, this applies especially to such projects that do not return any new archaeological finds at all. Even in archaeologically dense areas, excavation covering large areas often occur without finding anything that can be directly related to human activities in the past. However, to the modern land developer, the (pre)historic 'emptiness' is the most valuable fact and it can be of significant value for researchers as well. An archaeologist should not assume that 'emptiness' is a random prehistoric phenomenon. The saying 'the absence of evidence is not

the evidence of absence' certainly applies to archaeology. Complex taphonomic processes and a long range of potential inaccuracies relating to excavation and documentation methods have an impact on what eventually ends up in the documentation. 'Emptiness', used with this caution in mind, can be informative in many ways, especially when combined with the information of presence or absence of features in surrounding areas (Thomas, 2013, p. 100).

The questions archaeologists can ask depends on the archaeological documentation available. Information can be useless for one set of questions but might be very relevant for another, and especially for questions not yet conceived. As the chapter of Börjesson and Huvila points out, it is problematic to consider a written report as the main output of the documentation of an excavation. Without the infrastructure to search through both reports and databases from the excavation, it becomes difficult, tedious and time consuming to identify relevant information from data that was never included or described in the reports.

Taken separately, most of the investigations with limited or absent archaeological finds tend to become rather useless and they will not contribute to our understanding of the past, as these tiny observations cannot be put together and used in secondary research. Contract archaeology is usually concerned with isolated investigations where there seldom is time or initiative to collect and work with information from older excavations. However, when information from different excavation projects are aggregated so that the information can be reused, they start to show a greater whole in an image that cannot be seen from the individual pieces of the puzzle.

Sometimes this happens when a large infrastructure project calls for a series of archaeological investigations within a larger joint project, such as with the construction of a major new railway. As it happens, the size of these projects makes them *spectacular* by themselves. As spectacular development-led projects with 'unique' budgets, they benefit from bringing together information from several excavations and help to raise questions to a landscape level, rather than the point-like nature of individual excavations (Thomas, 2013). Such large projects can often give considerably new information about land use and prehistoric settlement patterns simply by bringing results from different excavations into a larger synthesis that otherwise would be missing.

With extensive projects like these, spanning both large areas, as well as a wide range of sites from different periods, comes the added benefit of a general analysis of the development of the affected landscape. These often include geological surveys and analyses that can provide information on land use and changes in it, as well as the significance of emptiness. Together these excavations can help to disclose something of the bigger picture: how certain types of archaeological structures are distributed in time and space, and how a new understanding of historical developments requires more than arbitrary results from isolated excavations.

As discussed in the chapter of Börjesson and Huvila, efficient archiving of archaeological information has the capacity to facilitate the reuse of already published data. Aggregated information can be incorporated in new analyses,

new methods can be used and new questions asked that are specific to the information brought together from several different sources. This will help to obtain new knowledge from old data, and a good approach for exploiting material that may not have been used to its full potential. With the increased longevity of information in digital format, archaeologists can now, for several decades, come up with new questions to previously collected data that requires computational support to be answered. As a society, we are increasingly 'thinking with machines' as we are dealing with larger volumes of data. The questions this give rise to are enabled and inspired by the latest technologies for analysis and can sometimes even inspire the development of new technologies. The data that we are working with remains as it was at the time when it was collected, in shapes and formats that might not always be ideal for further analysis. Hence, there is a collision between regimes of information work, those of the creation of data and its reuse for research. An often-referred example of the benefits of large-scale reuse of research data is the development of genomics and the advances in medical science that is continuing to spring from the sequencing of human DNA (O'Driscoll et al., 2013). In archaeology, we can see some early examples of these benefits with the use of 14C data, a type of information that is well defined and with less noise in the data compared with many other types of archaeological information; 14C is thus more readily aggregate-able for the analyses of long-term trends, statistical remodelling and for the use in answering such research questions that aim at new generalised knowledge regarding long-term social development (Eriksson, 2009; Herschend, 2016). Most archaeological information is, however, more difficult to combine and reuse in new contexts.

A wealth of archaeological information

With the use of digital technologies for documentation of excavations such as total stations, GPS and three-dimensional spatial technologies, every single excavation has a potential to generate large volumes of data that can be stored, retrieved and analysed from a range of perspectives. As discussed elsewhere in this volume, digital technologies can bring an excavation to a museum exhibition with high-quality visualisations of the site and excavation process. Data is also being curated to an increasing extent, with extensive investments in research infrastructures to give archaeologists access to information on a scale never seen before (Moore et al., 2013) even if, as a whole, as Börjesson and Huvila note, there are many obstacles in the way to comprehensive data repositories. Many research projects invest time to make sure that the information generated through the project will be available for others after the project has come to an end. Having a strategic plan for data management and dissemination is also becoming an integrated part of research funding, in line with the demand for opening both research results and data for others to use. There are also projects that are directly dedicated to making hidden information available to the research community, for instance, using advanced algorithms for image classification in order to enhance the possibility of making such information searchable, which had been

earlier more or less inaccessible (Makridis & Daras, 2012). One example is the project, *Image Database Montelius*, which applies these techniques on a large scale to enhance reuse of image data. Using computerised image analysis tools to search through archives of images of archaeological artefacts, the objects can be classified to make it possible to do vast searches of the information contained in the images (Stadler, 2008). The program first identifies and singles out individual artefacts in composite images with several objects, then it classifies the objects to a typology. As such operations are fast in a computer, it is possible to process large volumes of objects and enable these to be queried and compared to another dataset. Results can also be mapped to describe patterns and spatial and chronological patterns. Being able to extract information about certain types of artefacts from specific chronological horizons from such large volumes of data can help in exploring complex cultural transitions that can be traced from variations on mundane burial goods like pottery and combs, thus giving new insights into underlying cultural processes (Stadler, 2008).

There are several other projects that generate large volumes of information for the research community. The SPLASHCOS network (Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf: www.splashcos.org/) aims at bringing information about drowned prehistoric landscapes from the archives to a wider audience. The Swedish SEAD (the Strategic Environmental Archaeology Database: www.sead.se/) 'is a national research infrastructure for archaeology and an international standard database for environmental archaeology data'. Both initiatives harvest data from publications and make it possible to use that information in new research. Another initiative that focusses on making spatial information on ancient sites available for research and other purposes is Pleiades (https://pleiades.stoa.org). This project builds on the location of sites drawn from different types of available sources. By creating a general platform for collecting and sharing spatial information on sites from classical antiquity, the infrastructure can help pinpoint the accurate location of diverse sites mentioned in texts even on the basis of an individual, often ambiguous, mention, where it might be difficult to know its exact location. Pleiades also provides a function to contextualise fragmented information about locations. Information about a site can be linked to its geographical location, bridging the changing names of sites and the different origins of sources while providing information about it. These are but a few examples of how the research community is generating archaeological databases with the aim of harmonising and bringing them together, making them reusable and to open up for research questions that take advantage of huge volumes of data as their point of departure.

Data from contract archaeology

With all the effort invested in curating and disseminating databases from research projects, the absolute majority of new archaeological data is, at present, generated within contract archaeology. Depending on the national legal situation, it can often be difficult to apply policies for data management and longevity that can

accommodate the needs of the different possible end-users of the information. When databases from archaeological excavations are archived at digital repositories, they are usually checked for data integrity to ensure that they can be opened and used (Moore et al., 2013). Some of the information may then be converted to formats with an open licence or that are better for long-time preservation. However, the content of the information is generally left more or less as it is, without revising it to comply with any standardised data scheme. There are obvious problems with the practice of storing data of a similar type and origin in a way where it is difficult to compare and combine datasets with each other (Perrin et al., 2014). For instance, one excavation may have opted to separate all archaeological features into separate layers, whereas another project might have combined all polygons recorded into one and the same file. Here it is often the individual needs of each excavation that determines the way information is described. A small excavation undertaken by one person for a few days will have very different needs for documentation compared with a project that extends over several years and includes hundreds of archaeologists. If there are no predefined data structures for how the final documentation should be organised, there will be little initiative to plan for, and maintain, a large complex database for a project that only has a few hours of field work. Moreover, as every archaeological site could be labelled 'unique', some archaeologists feel that documentation must be extensive and flexible in order to respect and preserve the character of the site. Consequently, they will be reluctant to conform to a certain way of documenting their fieldwork.

The perspective of someone that wishes to reuse data and combine the information from several excavations in order to compare these might be quite different. In this case, there would be huge benefits if the information was as standardised as possible. However, implementing standards of data structures in retrospect, on information of a heterogeneous origin, is time consuming and difficult because it runs the risk of misinterpreting information and introducing errors. Therefore, it is not common to rework the data contents of general excavation databases before archiving them at repositories. For research purposes, nevertheless, there is a need for structured information and hence data needs to be reworked.

Another context within which there is a need to get a comprehensive overview of all prior excavations is cultural heritage management. As any given region might have archaeological interventions of different types and scale reoccurring in the same area over long periods of time, it can be a difficult task to keep track of where excavations have been carried out and what the results were. If this information cannot be retrieved and taken into consideration, decision-making on land-use related issues may require new excavations in an area that has already been excavated.

Harmonising GIS data from excavations

As archaeological data is becoming more available for research, many new projects have emerged that aim to make use of the opportunities to generate new

knowledge from existing data. So far there are few examples of data from contract archaeology being used for research on aggregated data in Sweden. This is probably because it is still difficult to access such data, and the data does not come in a format that can easily be used for analysis. Sweden has a long history of documenting excavations using digital technology, such as GPS and total stations, and hence much data is created every year. However, this data seldom leaves the organisation where it was created. Only a very limited subset of the information is transferred to the national repositories. This is a problem both for academic research and antiquarian authorities in need of an overview of all previous excavations. Due to the problems retrieving data from previous excavations, this information has so far rarely been reused for purposes outside the original excavation. In 2011, the County Administrative Board (CAB) in Östergötland, Sweden, initiated a collaboration with Uppsala University in order to collect the GIS files from the documentation of excavations. The aim was to make it possible to create overviews of the extent and results of excavations enabling the CBA to know exactly what areas had been excavated and where archaeological remains had been found. At the same time, this was an opportunity to explore the potential for working with aggregated data from contract archaeology excavations, and to test the usefulness of new computational techniques to these types of datasets. Hence, in addition to responding to the direct practical needs of the CBA, the project was also carried out with the needs of possible future research applications in mind and the data set was used as a testbed for aggregated analysis of excavation data. In the following, we will explore some of the potential issues and benefits identified during the course of the work relating to the use of accumulated contract archaeology data resources for cross-site analysis in research projects.

The project ran for a total of about three months during the summers of 2011 and 2012. The first ambition was to collect and harmonise available digital data. In comparison to digitising analogue information, born-digital and already digitised information is easier and less time-consuming to use as a basis for generating unified information. However, even if the information was in digital format, the data structure of the files varied considerably when they were obtained from the different contractors. Even if some of the projects had been documented with the same documentation tool, Intrasis (www.intrasis.com), the files looked very different from project to project because the system can be configured to account for different documentation needs and work processes. In other cases, it was necessary to convert the format of the GIS data and reproject the coordinate system to ensure that it was possible to work with the files. When all data was readable, it was harmonised by transforming to a set of predefined templates so that the main structure of all the files would be identical. The layers chosen to describe all the GIS data from the different excavations are shown in Table 2.1.

The initial part of the table for of each file is similar, with a fixed set of identifiers. These consist both of new identifiers created as part of the harmonising project, as well as the original identifiers created during the original investigation.

Table 2.1 An overview of the different files used to describe the information from archaeological investigations and excavations

Trench	A polygon (area) layer with the extent of areas excavated.
Archaeological features	A polygon layer with everything archaeological documented as an area.
Lines	Everything documented as a line.
Points	Everything documented as a point.
Other	A polygon layer with all areas not interpreted as archaeology.
Project	Metadata about the project, with administrative information linking to further information sources.

The new fields added to the dataset contained basic information such as trench name, feature and find number, as well as an additional free text field that can give information about the context of the feature, for example, what building a post hole belonged to. This procedure created a very basic structure with only the most important information, as seen in Table 2.2. However, when there was additional information, as it is often the case with digital documentation, all fields were kept as they appeared in the original data and added to the dataset, so that no information was omitted. The information that is most commonly used is thus ready to query in the standardised first section of the table. For those who need to dig in deeper into the data, all existing information would still be available even if it would take some more time to identify, as there is no fixed structure in how it is described (see Löwenborg, 2015).

In addition to the information recorded during the excavations, a full metadata of all the excavations was also created. Metadata connected to the individual excavation databases themselves was fragmented, unstructured and often completely missing. It could thus be difficult to connect the excavation to the correct report, which means that even if the data was accessible, it would be of limited use. The metadata of all projects was also created as a shapefile to fix the project metadata in space.

The project continued in 2014 as part of the planning of a large new railway through parts of Östergötland and its neighbouring counties. The project is called *Ostlänken* (Eng. East Link) and represents a major infrastructure investment to a new high-speed railway line that was started to be built in 2017. It stretches for 200 km between the cities of Stockholm and Linköping. As there was a need for extensive archaeological investigations ahead of the construction of the line, there was an urgent need to have as much information as possible about earlier excavations in the area. The original 2011/2012 database only partially overlapped with the area that would be affected by the new railway. A project was thus established to complement the existing database with excavations from the missing area. Because the project required a full biography of investigations in the affected area, it was not enough to only collect digital data. All excavations and

Table 2.2 The header of the table used for all GIS data files. These provide structured information about the data in an accessible way to make it easy to merge data files from different sources together. After these initial header fields, all additional fields of the original data were preserved, but in an unstructured way that would make it more difficult to query

ID	Internal identifier for the project, created by us.
Category	Basic description of data object. Category of archaeological feature, type of excavation trench, find or another object.
Feature number	Name or number of find, feature or trench, etc.
B_ID	Original identifier as recorded in the field, i.e. by the total station or GPS. This was adopted from the Intrasis system of describing original identifiers.
Text1	Free text field, to highlight most relevant context or information, where relevant.

investigation from 1959 and later, which had been carried out in the corridor of the railway, was georeferenced and digitised using the same templates that had been used before. The main aim of collecting and digitising excavation data was to enable planning of further archaeological investigations by generating detailed information about where previous excavations had taken place. Therefore, it was primarily the extent of the trenches that was required for planning purposes. However, in order to test the possibilities of analysing aggregated volumes of excavation data, additional digitisation was performed afterwards as part of the ARKDIS research project, so that the individual archaeological features were included. This means that a subset of more detailed information is available for further modelling and analysis of archaeological phenomena using this large dataset.

The whole project includes a total of 527 excavations. After the project, a harmonised GIS dataset with more than 18,000 archaeological features was created. The excavation projects are of varying size and while a few generated a large number of archaeological features, the majority are trenches without any finds at all. The official part of the project lasted two months, with five people working full time, and in addition to full-time staff, we had interns that continued to work on the data doing additional digitisation tasks. The time invested in creating this dataset, which covers a fairly limited part of the region, amounts to about one year in total. The data gathered and reworked was sent to the Swedish National Data Service (SND: https://snd.gu.se) at the University of Gothenburg for keeping and dissemination. SND is a national research infrastructure, comparable with the Dutch DANS (http://dans.knaw.nl) or the UK Data Archive (www.data-archive.ac.uk), which stores and disseminates humanities and social science research data so that the information can be reused for other projects. SND has used the deposited data from the *Ostlänken* project as part of the work with the ARIADNE infrastructure (www.ariadne-infrastructure.eu), to develop the prospects of sharing archaeological GIS data internationally.

Archforest – a test of statistical machine learning in archaeology

Whereas the *Ostlänken* digitisation project explored the possibilities and challenges relating to producing harmonised datasets of heterogeneous contract archaeology data, another experiment was launched to inquire into the opportunities for analysing that data. Many new methods for analysing large datasets has been developed in the context of computer sciences. Many of the approached use computational statistics and mathematical optimisation that can handle complex and non-linear relationships. Closely related to developments in artificial intelligence and automatic classification, statistical machine learning 'encompass automatic computing procedures based on logical or binary operations that learn a task from a series of examples' (Michie et al., 1994). These methods have much in common with traditional statistics, but through the application of specially developed algorithms and the use of computers with high processing power, it is possible to work with highly complex mathematical operations on large datasets. This leads to interesting possibilities in terms of analysing problematic datasets with missing information, reducing noise and identifying the features that carry the most important information, as well as sophisticated methods for model evaluation and generalisation (Hastie et al., 2009).

In order to test the potential of working with such techniques in archaeology, a small pilot study was designed that would apply statistical machine learning techniques for predictive modelling (PM) using the dataset of archaeological GIS produced for the *Ostlänken* project. The primary goal of PM in archaeology is to estimate the location and density of archaeological sites. The purpose of PM is often to facilitate planning and cultural resource management, where it is essential to predict concentrations of unknown archaeological features in order to make management plans for their preservation, or to estimate costs for the investigation and excavation of sites in an area needed for land exploitation. There are also examples of when predictive modelling has been used for research purposes. With the increasing availability of archaeological information, the use of PM in academic research will probably increase. While sometimes accused of having a bias towards environmental explanation and determinism, there are definitely instances where the statistical modelling of spatial relations in an archaeological material can aid interpretations. One reason why PM has not been used to explore research questions as much as it could, might be that it is has been seen more as a tool for cultural resource management than for academic research (Verhagen & Whitley, 2012, p. 50). In order to predict where and how many sites that might be located in areas where there is insufficient information from observation, different methods have been applied to give an estimate of concentration of sites. The main technique for PM in archaeology is logistic regression, with much work being put into defining variables that describe both historically relevant natural landscapes and aspects of a cognitive nature to have more human agency integrated in the analysis.

To experiment with statistical machine learning in the context of archaeological PM, a collaboration was established with the Department of Computer

Science at Uppsala University. Bachelor student Anna Nilsson wrote a program in the R language, called *Archforest* (Nilsson, 2016) based on the *Ostlänken* data, to explore what potential benefits of using these tools could bring to archaeological PM. The scope was to define a model to predict densities of archaeological sites from the training set of GIS data collected for the *Ostlänken* project. A set of variables describing landscape characteristics that could be used to estimate densities were calculated in GIS (Table 2.3).

After extensive testing of different methods, a *decision tree/random forest* approach was chosen as the most promising method for this purpose and the *Ostlänken* material. The decision tree model is a classification method that can generalise to regression, and is particularly strong in working with complex data that are seemingly random. A simplified way to describe the decision tree method is to think of a dataset that needs to be classified so that each class has its own definition, or branch. The methods work by dividing the axes of the dataset in two at the optimal place. This creates two different branches, and if one branch only contains one type of elements, all from the same class, then the process stops there. Otherwise, it will keep dividing the data in continuously more branches until each branch only contains one type of element class (Figure 2.1). The result is a very accurate definition of the tree representing the variation in the dataset, with the downside of being highly biased to the training data. This bias can be compensated for in several ways, and the random forest function does this by

Table 2.3 Variables calculated in GIS describing basic landscape characteristics used for modelling

Y-variables	
Count	The number of archaeological features found in a given trench.
Area	The area of a given trench.
X-variables	
Spatial data	
x–coordinate	Centroid of trench, easting.
y–coordinate	Centroid of trench, northing.
Feature data	
Elevation	Elevation above sea level.
Land type	Modern land type, such as forest, open land, built up, etc.
Rock type	Type of bedrock.
Distance to water	Distance to closest water, sea, lake or stream.
Slope	Topographic slope in degrees.
Aspect	Aspect of the topography in compass degrees.
Soil type	Characterisation of modern top soil.
Soil depth	Depth of soil above bedrock.
Distance HL	Distance to the closest stream.
Distance 1500	Distance to shore line as calculated for 1500 BP.
Distance 3000	Distance to shore line as calculated for 3000 BP.
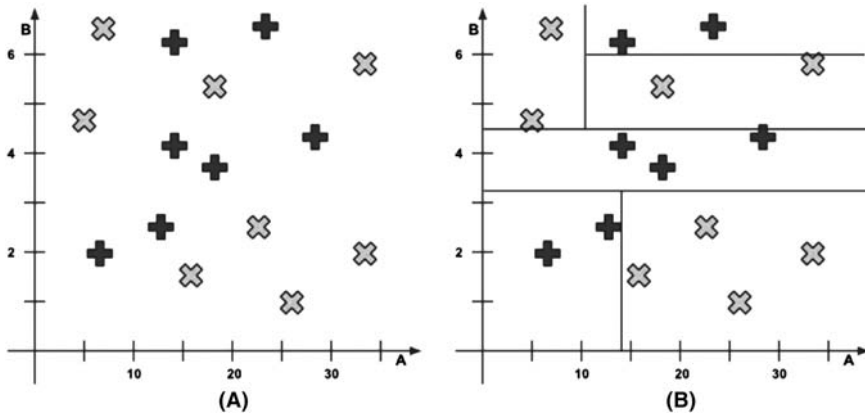
Figure 2.1 An illustration of how the decision tree algorithm subdivides the axes of the dataset until each branch contains only one type of class (Nilsson, 2016).

repeatedly taking a random subset of the training data to build decision trees. A large number of decision trees can be combined by majority vote for classification purposes or calculated as a mean for regression predictions (Hastie et al., 2009; Nilsson, 2016).

Evaluating the performance of the *Archforest* program is not trivial because the success rate can be measured in many different ways, depending on if the question is to find areas with a low risk of disturbing archaeological remains or a high chance of finding new, previously unknown sites for research purposes, and so on. Further, there are different ways to interpret the results in terms of their probability in giving a false-positive outcome, or a false-negative result. As part of the project, extensive computational methods were performed as part of developing the program (see Nilsson, 2016).

Compared with a standard logistic regression model calculated in SPSS, *Archforest* seems to perform at a similar level, but at this point could not be seen to improve the output to a significant extent. While the dataset is large from an archaeological perspective, it is not necessarily large or complex enough to benefit from the algorithms of machine learning techniques at this time. At the same time, this test of using statistical machine learning highlights several issues that needs to be addressed in order to improve results in the future. A major issue is the substantial bias inherited from how the data has been collected. All archaeological data used in this example comes from contract archaeology investigations where sites have been excavated and removed to make room for new constructions, roads, railroads and buildings. This type of work tends to be located in a certain part of the landscape, usually in close proximity to modern urban areas. There are underlying correlations between modern and historic land use meaning that some parts of the landscape are more likely to be subjected to archaeological investigations, while other parts are more or less untouched by archaeologists and

any archaeological features therefore remain unknown. Further, while initial trial trenching might be carried out for large parts of the area affected by land development, they are usually more intense in areas that can be expected to contain more archaeological remains. The risk of missing sites during trial excavations might thus be larger when there is a low expectancy to find sites. And when a site is found and selected for intensive excavation, there will be much larger areas opened during this phase, resulting in an over representation of the size of excavations in those areas where archaeological remains are found. All these issues can be addressed and compensated for in statistical analysis. These are merely a few examples of factors that was beyond the scope of the first phase of the *Archforest* experiment but that gave promise for continued work with developing the approach.

The case study serves as an example that illustrates some of the possible ways forward of harmonising heterogeneous data and working with the harmonised data. Thinking along the lines of what might be possible when working with aggregated data from contract archaeology illustrates a different attitude to the information work in archaeology, where the results of an individual excavation retain their relevance long after the compulsory investigation report is filed away. If the data can be reused for further analysis of aggregated data, this will open up a wide range of questions that go beyond the scope of the conventional archaeological research today.

Discussion

The expectations on what research archaeologists can do with all the accumulated volumes of archaeological data are high. There are substantial general expectations in contemporary society of the ability to use powerful algorithms and 'Big Data' together with the development of artificial intelligence to alter the world as we know it (Lane, 2012). What this will mean for archaeological research has been much debated and the use of Big Data in archaeology has been seen as a step towards a new paradigm in archaeology (Gattiglia, 2015), especially when combined with parallel developments in natural sciences, including the use of ancient DNA (Kristiansen, 2014).

When approaching archaeological information for aggregated analysis, we are often faced with the problem that the information is not standardised to the required level for this kind of approach (Huggett, 2015; Thomas, 2013). This might well limit the development of archaeological research based on large volumes of data and prevent information from contributing as much as it could to the production of new knowledge. The workload of transforming the information to the required format is time consuming, and can represent a major investment for a research project. Archaeology is special in this respect because information is produced as the original information carrier, that is, the archaeological site being excavated, is destroyed. Hence, it is necessary to include the information of the previous decades and incorporate this in a dataset, as it is not possible to duplicate that information or go back to the

original sources to complement the information without the original reports. A major problem here is that the practice of field archaeology is constantly changing and developing in terms of the methods of excavation and documentation, as well as in terms of the priorities in the whole process of cultural heritage management. But without the information generated through excavations of previous decades, we would have very little to base our archaeological interpretations on. To push the development in archaeological research and to be able to benefit from the computational analytical methods, these issues of how to incorporate 'old information' needs to be addressed, something that will probably require a large amount of manual editing and rework to be realised.

At the same time, there are also many risks involved with the standardisation of information, no matter how thoughtfully it is performed. Often each research question will require its own approach to how the data is organised, structured and described. Archaeological data is usually not straightforward to harmonise, and it is important that the unique character of the documentation is appreciated and accounted for, especially when the information has been collected over a long time and with a wide range of different methodological approaches (Cooper & Green, 2015).

Much effort is now invested in making sure that archaeological information can be made available through national and international infrastructures. The European ARIADNE infrastructure project has ambitions to join information from the national archaeological information infrastructures, and by developing an aggregate search service, to overcome the problems of sharing information across borders when there is no commonly agreed standards or metadata (Niccolucci & Richards, 2013). With further development in automated processing and clean-up of the data, it might be possible under certain conditions to apply technical tools that will aid work on data without extensive remodelling of information (Cooper & Green, 2015). Nevertheless, manual intervention will often be necessary, especially when working with old data, be it digital or analogue. A delicate matter is the question of how much standardisation can be expected of data that will be produced in the future. A lot of time could be saved if archaeological documentation was created in a standardised format from the start, in comparison to doing this afterwards at an infrastructure facility, when much of the specific knowledge about each dataset has already been lost. However, there are significant problems with imposing high levels of standardisation on the data structure of field documentation. One concern is that it will simplify the information collected, and thus make it less relevant, or perhaps only relevant for a certain type of question, but of limited use for other purposes. This might also influence the whole practice in the field, how excavations are planned and executed. If there are very specific demands on how and what information to collect in the field, then this might lead to a situation where certain kinds of archaeological features are prioritised and others ignored. Prioritisations will always be made, but if the requirements on the documentation lead to an increase in structured biases in what is recorded,

and even to what sites are selected for excavation, the setting of priorities would have major negative consequences. An example from Swedish contract archaeology is the situation up to the 1980s, before the emergence of the widespread use of excavators to clear the topsoil. At this time, there was a general consensus that no settlements were located on clay areas during pre-history. Hence, clay was not prioritised for excavations, a situation that con-tributed to few settlements being found on clay. This situation changed dramatically when it became more common to clear off the topsoil of large areas, a practice that resulted in a dramatic increase in the discovery of settle-ments in these conditions.

On the other hand, one of the most exciting prospects of using mass data would be the new research possibilities this would lead to. Computational methods in archaeological research are gaining in impact with the technical advances in general, but there are many fields that are still underdeveloped. Predictive modelling, for example, has mostly been used for cultural heritage management, and to a lesser extent, in academic research because the approach has often been seen as theoretically underdeveloped and weighed down by environmental determinism (Verhagen & Whitley, 2012, p. 50). Nonetheless, the methodologies involved in predictive modelling are being fine-tuned and it is an active field of research. Both the statistical techniques that are used are improved, and the theory behind the modelling and variables used to account for cognitive aspects are discussed and evaluated. With an informed theoretical perspective, predictive modelling could be of great value for academic research in explaining the differential spatial patterning of archaeological sites (Verhagen & Whitley, 2012).

With access to large volumes of archaeological data, one of the most fascinating opportunities might be to work with open questions, where exploratory data analysis could be used in order to find unexpected patterns in the data. A risk with a highly specialised question, focusing on a certain type of phenomena or artefact, might be that we fail to recognise the larger picture of our object under study (DeMarrais, 2013, p. 346). Large amounts of information, on the other hand, will often inspire grand narratives, examining phenomena on a large scale of space and time. This might be in the writing synthesis of the development of large regions from a landscape perspective, or studying long-term social change, such as the social consequences of the AD 536 climatic event on social organisation in Scandinavia (Gräslund & Price, 2012; Löwenborg, 2012). In order to study such large-scale phenomena, it would be necessary to have the data in a format that can facilitate general analysis, suitable both for specific research questions and for exploratory data analysis and data mining.

Conclusions

It is clear that there are exciting possible future advances to be made in archae-ology by applying the emerging computational methods and algorithmic

approaches. To see the real potential of these methods and to apply them to archaeological research would require larger data sets and more work, but we can start to distinguish some of the potential of working with more archaeological data that is readily available for analysis today. Access to data and reuse of information will be crucial for this field of research to develop further and to realise the full potential of working with quantitative methods. In this way, the vast amounts of information that are produced can hopefully be used to generate new knowledge more effectively than today. Better structured archaeological information in a format that is readily readable also means that it will be possible to benefit from this information in several other sectors outside academic research, for example, in cultural resource management. These effects would be hard to accomplish with archaeological documentation that is predominantly internal and focuses on the single sites by themselves.

The problems of how to define archaeological information are far from trivial, and there are dangers involved with enforcing strict data schema to describe the messy reality of archaeological excavations. On the basis of the experiences of the *Ostlänken* project, a recommendation is to allow the documentation to remain messy and give the archaeologists the liberty to continue to describe each excavation with the specific requirements of the site. However, in addition to that, it would be important to add a simplified 'header' to the information, similar to the one used for *Ostlänken*. Having a simple header with a standardised set of attributes that describes the most important aspects of the information with some general categories of data contents makes the dataset considerably easier to reuse. With a standardised header, it will be possible to aggregate the information for high-level analysis by combining information from many different sources. The concern that the use of a simplified header might lead to general simplification of documented information is an important issue that needs to be considered. However, not taking action to ensure elementary data interoperability over time and across different systems runs the risk of hampering the use of information from excavations for the production of new knowledge. As archaeologists are getting better tools available for the analysis of large amounts of data, this is an area with great potential to expand our ways of understanding the past. With the archaeological practice of today being thoroughly digital, developing matching digital tools for knowledge production is one of the great challenges for modern archaeology.

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3   3D models and knowledge production

Nicolò Dell'Unto

Introduction

The way we record, organise and store archaeological information collected in the field is a crucial factor in the process of knowledge production. The instruments employed in the field to record archaeological evidence, as well as the typology of database used to store and organise data, represents just a few of the many options available today for recording material culture.

The current possibility of integrating new and different recording tools in aid of archaeological field documentation has destabilised the standards defined in the past, opening a phase of intense experimentation that has not yet come to an end. The definition of modern archaeological field practice in the pre-digitised society (20th century) was developed after a long discussion among practitioners in a period when no major computational technological development occurred.

Today, the employment of new recording methods in archaeological practice is immensely more complex and it involves the knowledge of tools, which are seldom part of archaeological training.

When working in the field, archaeologists must take into account the use of instruments, which allow performing operations of visualisation and analysis that were impossible to achieve before, those approaches are considerably behind the traditional way of conceptualising information in archaeology and require the development and adoption of new and more dynamic visualisation methods.

The introduction of new instruments and techniques for field recording hinders the development of standards for practitioners, creating obstacles in evaluating the real impact of a particular technology in the process of interpretation. Specifically, the recent advances of three-dimensional (3D) acquisition and visualisation technologies and the consequent diffusion of 3D information – produced as a result of a field acquisition campaign – has exposed the discipline to new and challenging scenarios; 3D models were considered revolutionary in archaeology even before the proliferation of their use (Forte & Silotti, 1997) and, since their first applications in the cultural heritage sector, expectations from the community of researchers have been very high. Already in the early 1990s, a discussion concerning the impact of this new type of information would have on future research took place in the literature, proposing

new and exciting visions on how future technological development in 3D visualisation technology would transform the discipline from both a theoretical and a methodological perspective (Reilly, 1991).

Colin Renfrew, in his foreword to the book *Virtual Archaeology*, explained how computer-based visualisation would force archaeologists to interpret the past in a more logical and structured way and how by creating an 'atlas of archaeological models', it would be possible to provide archaeologists with alternative methods for interpretation (Renfrew, 1997). Despite the initial enthusiasm, however, the vast computational resources required to support the diffusion of the use of novel visualisation techniques, the difficulties in merging such new visual data into more traditional interpretation processes, and the lack of knowledge from heritage interpreters on how to employ these new datasets, represent obstacles for the development and spreading of this approach. In her article 'Crafting knowledge with (digital) visual media in archaeology', Perry discusses how the relationship between visualiser and archaeologist has profound implications for the knowledge production process, and underlines how today the 3D visualisation of the archaeological record often depends on specialists without any formal training in archaeology (Perry, 2015). The lack of trained professionals, with both of these competences, has hindered critical discussion of the impact of these types of media for recording, visualising and analysing archaeological data as part of the process of interpretation, as well as the definition of limits and potential of these new datasets for obtaining new information.

Recently, the exponential diffusion of visualisation technologies in multiple sectors of society and the rapid distribution of low-cost instruments and techniques for 3D recording created prerequisites for a large-scale production of 3D models in support of archaeological field activities. Already in 2014, Olson provided accurate indications concerning the impact that these types of data are having on archaeological practice (Olson, 2014). This trend can be recognised to be a result of a conjunction of events, which can be summarised as follows:

- The recent development and diffusion of low-cost techniques and instruments for 3D data recording and visualisation in the archaeological sector.
- The start of a theoretical and methodological discussion concerning the impact of these new types of data in support of archaeological practice.
- The development of several significant experiences where the use of 3D technology proved to be an important component in support of archaeological interpretation.

Among the different results produced by the implementations of these media in the cultural heritage sector, the one which recently got most attention, has been the worldwide production of 3D digital libraries of monuments and collections under threat or with a limited availability.

The general idea behind this approach lies in the possibility of having these archives available in the future for researchers working in the cultural heritage sector. However, the diffusion of such practice without previously developing a

critical frame for evaluating the real possibilities offered by 3D models, or an assessment on how different practices in creating those data affect the work of different specialists, could lead in the future to the creation of large collections of datasets incapable of providing sufficient information to support research. Three-dimensional models emerge in fact as a result of a number of choices made by the operators to address specific research questions, and their characteristics reflect (1) the types of instruments chosen for acquisition; (2) the kind of acquisition process performed by the operator; and (3) the type of post processing that is applied to produce the final visualisation. In order to be useful in the future, these datasets must meet certain quality standards, must be documented with a certain degree of rigour and they need to be linked and related to other visualisations using shared concepts (Kansa & Kansa, 2013).

As archaeologists or cultural heritage interpreters, in order to understand how a large diffusion/production of 3D data in the cultural heritage sector will affect our practice, we should focus on defining a critical frame for the identification of the real impact that data can have on the current investigation paradigms. The development of such a process would allow determining the role of this new typology of media in the complex process of interpreting the past, and, as consequence, in defining new concepts of archaeological information.

In the context of this chapter, I will discuss concepts, including quality and transparency, from the perspective of the representational characteristics of 3D models. Moreover, through the presentation of different case studies, I will demonstrate how the production of 3D models allows producing relevant archaeological data as result of an active participation in archaeological field investigation activities.

Potential and limits of 3D models

Three-dimensional objects have been employed in archaeology since the beginning of the 19th century (Kockel, 2004). The use of plaster copies or models of ancient material were a diffuse practice in museums collections and academic environments (Huvila, 2006). These objects were mainly employed in support of teaching, research and public display, and in several cases, represented the only chance to experience in a full or accurate scale, shapes and details of their originals. Although the practice of physically copying an object does not have such a large diffusion today, still, several universities own and use collections of plaster cast copies in support of didactic activities. By being part of a physical/interactive space, and by being recognised and used as 'objects of culture', in the last century, those creations gained their own identity, and, as result of this process, today are archived, conserved and treated as any other 'original' artefact. By gaining a personal biography or, using the words of Benjamin, *a new essence* (1968), and for the concept of being part of the past or having a past (Holtorf, 2013), the status of these creations, as well as their value, changed.

In the past, the development and diffusion of techniques for the mechanical reproduction of objects raised curiosity and attention among the public and

enabled intellectual discussion to extend to a larger audience of scholars, which could rely on these creations to support new theories and interpretations. Different from pictures or drawings, physical copies provide users with the opportunity to review the geometrical characteristics of an object, which can be explored from multiple perspectives. By engaging in a process of physical (and even tactile) interaction, it is possible to gain a deeper understanding of the artefact itself (Di Giuseppantonio Di Franco et al., 2015). Since the introduction of mechanical reproduction techniques, a discussion concerning the use of such practices as a way to get hold of an object by its reproduction has taken place in the literature (Benjamin, 1968).

Today, with an exponential diffusion of more advanced documentation techniques, such as 3D modelling and 3D prototyping, similar considerations have been raised, especially in relation to the practices of creating libraries or collections of three-dimensional representations of monuments and artefacts, aiming at digital preservation of the originals (A. Busacca, submitted manuscript, 'If you destroy something we can rebuild it again': the million image database and the technological promise of ultimate reproduction). Recently, this particular practice has been promoted as a response to the destruction of cultural heritage sites and monuments in war, natural catastrophes and looting. Specifically, after the Taliban attack on the Buddhas of Bamiyan in central Afghanistan (2001), the use of 3D acquisition instruments and techniques to virtually record sites and monuments under threat grew exponentially. The increased awareness and media attention of the loss of tangible heritage has induced more and more researchers to consider the use of 3D technology as a central means for heritage preservation.

A practical example of this is the work of several non-profit organisations, such as CyArk (www.cyark.org/about/). They have used 3D acquisition technologies since 2003 to create a 3D online library of world cultural heritage sites under threat. Another example is the Million Image Database project, which through the help of dedicated volunteering photographers, is collecting high-quality scans of important sites in conflict zones, aiming at creating a large database that will be used for 'research activities, heritage appreciation, educational programs and 3D replication' (http://digitalarchaeology.org.uk/projects/).

The use of 3D for heritage preservation contributed to the rapid emergence of a large number of 3D archives. The production of these collections has been most often justified by their capability to facilitate the diffusion and democratisation of access to cultural heritage data. Despite the fact that several 3D collections are now available online in different forms, it is not clear how those data (once stored) are used by other specialists or non-professionals to produce new knowledge. Is this data democratisation process really taking place? And are the models stored in these new archives capable of serving the needs of different stakeholders across the cultural heritage sector?

A single 3D model contains a large body of information. For this reason, the definition of a good practice for its production and archiving is a far more complex task than for any other type of graphic dataset. The practice of creating

3D libraries is also expanding among archaeologists, who are increasingly using these techniques for landscape and field documentation to gain more realistic visualisations of features and contexts detected during field investigation. This 'huge' production of 3D data has caused concerns among practitioners that, in producing an archaeological record, stresses the importance of keeping a good balance between the capturing of data and intellectual reasoning with the material being recorded (Giuliani, 2008; Kansa, 2016; Opitz & Johnson, 2016; Powlesland, 2016). In introducing the concept of *Slow Archaeology*, Caraher expresses scepticism that instruments and technologies, which focus on accuracy, efficiency and consistency alone, will benefit archaeology (Caraher, 2016). A similar discussion was already undertaken by Giuliani (2008), who, discussing the introduction of new instruments and techniques for the digital documentation of monuments, warns archaeologists against the risk of losing intellectual engagement with the material itself, stressing the fact that documentation is not just a mechanical operation to record the geometrical characteristics of a monument, but a process (probably the only one) that allows us to gain a deeper understanding of the monument itself.

> *il rilievo non è una mera tecnica destinata alla documentazione, ma un mezzo di studio, forse il solo, che consente la conoscenza dell'edificio e che avere tra le mani una stupefacente immagine elettronica non vuol dire affatto aver compreso il documento* [and] *[il rilievo digitale] ha dato ancora di più ai non addetti ai lavori la sensazione che per capire l'edificio, sia sufficiente avere materialmente il rilievo.*
>
> (Giuliani, 2008)

> *Graphic record is not anymore a mere technique of documentation but a means of conducting research. But having that record, which enables us to know about a particular structure and provides us a breath-taking digital image of it, does not mean that we would have understood it [and] for those who are not familiar with the work [of obtaining the record], it has given an even stronger sensation that having the record is enough [for understanding the structure].*
>
> (Giuliani, 2008)

In describing the benefits of using 3D technology for recording archaeological deposits, Powlesland (2016) underlines the importance of producing data as a consequence of a direct observation and interpretation on the ground, pinpointing the risk of the ones less engaged in the field to believe that this approach can speed up the excavation process. Both Giuliani and Powlesland make an important point, namely, that direct, non-mediated engagement with the 'real thing' (as opposed to the 3D model alone) is paramount to the understanding of the archaeological material and that the production of knowledge is entwined in the mundane practices throughout the continuum of archaeological work.

The general impression is that in order to make data significant in the context of the process of interpretation, it is important to start considering that the quality is

not only defined by such characteristics as accuracy and resolution, but mainly by the efforts of the interpreter in making the resulting model as representative as possible of the specific characteristics, which he or she intends to record and transmit. For this reason, the data should aim as much as possible at reflecting and emphasising the observations, which accrued as a result of an intellectual engagement with the material.

Despite the possibilities of modern technology to produce information, which carries a strong resemblance with the original material, it is necessary to consider that the production process of a 3D model is strongly affected by: (1) the typology of recorded materials; (2) the instruments and techniques used for acquisition; and (3) the research questions formulated in the context of the investigation. For these reasons, an archive compiled with 3D artefacts and sites acquired without taking into account these aspects, could prove to be of no use for future generations and, in the worst case, it could be misinterpreted and lead researchers to wrong directions. Therefore, in order to understand in-depth how 3D digital artefacts can efficiently contribute to the process of knowledge production, an analysis of how 3D models impact current research projects could provide interesting information for better understanding the needs of different specialists in using this type of information in the future. As previously discussed, if many projects are currently focusing on more technical aspects concerning the construction of 3D libraries of cultural heritage sites and collections, very few attempts have been made to clarify the role of this information in the current process of knowledge production. It is urgently needed to create an understanding of the diverse theoretical underpinnings for potentially making distinct models for investigation, didactic and communicative purposes; each of these requires its own theoretical foundation as well as craftsmanship expertise. The development of such study would eventually allow defining guidelines and protocols for the production of 3D models capable of serving multiple types of research activities.

3D modelling is many things

When discussing 3D models in archaeology, an important aspect to take into account is represented by the variety of techniques available in generating a 3D model. If, from a technical point of view, it is possible to classify 3D models into specific categories, from a representational perspective, a 3D model is the result of an interpretation process, whose characteristics reflect the intent of the interpreter to represent and emphasise specific aspects of the information used as a basis for constructing the model (Garstki, 2016).

In spite of their capacity of displaying realism, 3D models do not incorporate the characteristics of the original objects in their entirety, and for this reason, the models should be considered not as a re-production, but as an original production of something different (Huvila, in press).

The gap between the multitude of possibilities offered today by the use of 3D technology and the current discussion concerning how different types of 3D information affect archaeological interpretation, raised concern in the community

of practitioners. If, on one side, there is a general agreement on the fact that 3D models are an important tool to incorporate in archaeological practice (Lanjouw, 2016), on the other side, questions concerning which techniques should be employed for recording archaeological material and how 3D models (especially as a result of a field acquisition activity) should be used in relation to more traditional records are still to be defined.

In order to identify when and where this type of information can be efficiently used in interpretation, we need to understand its real role and affordances in relation to the archaeological process. Despite the possibility to easily create and visualise 3D models during field operations today, it is important to take into account that their integration into a more reflexive discussion is often prevented by the complexity of visualising those data in relation with different types of datasets. My impression is that we are desperately trying to squeeze this new type of information into an investigation paradigm, which, by nature, is not shaped to digest these data. A consequence of this trajectory is the emergence of numerous examples where 3D models have been employed to visualise the final interpretation of the investigation without being used (as Renfrew suggested) in support of the process of knowledge production. A typical example is the widespread use of 3D models to generate bi-dimensional ortho-images to sub-stitute traditional graphic documentation, including hand or digital drawings.

In his book, *Practice of Archaeological Stratigraphy*, Harris describes how tra-ditional graphic documentation in archaeology was designed to provide a three-dimensional spatial and temporal access to the data recorded (Harris, 1989). The possibility of the benefit of a three-dimensional visualisation as a support for an ongoing archaeological investigation strongly impacts the data interpretation, affecting the possibilities of archaeologists to come up with increasingly accurate interpretations. The establishment of such a structure implies: (1) an increasing complexity of the organisation of data; (2) diverse use of the technology itself, which should be employed not only as a tool to record or visualise specific information, but also as the main system where accessing, visualising and inter-preting all the data collected in three dimensions; and (3) a clear understanding of why, when and how the 3D model should be created.

During the last decade, different experiments focused on testing the use of 3D visual technology in support of archaeological practice were explored (Callieri et al., 2011; Dellepiane et al., 2013; Dell'Unto, 2014b; Dell'Unto et al., 2016; Forte et al., 2012; Opitz & Nowlin, 2012) and several articles were published where 3D models were used as visual palimpsests to perform quantitative and qualitative archaeological analysis (Bevan et al., 2014; Garstki et al., 2015; Magnani & Schroder, 2015). The results of these experiments demonstrated how the introduction of the third dimension in support of archaeological thinking opened new possibilities for interpreting the past, providing researchers new ways of looking at archaeological data to test.

Due to the wide diffusion of novel digital acquisition techniques, specific sessions at international archaeological conferences (e.g. CAA, EAA, SAA, TAG) were organised to discuss the impact of new acquisition methods and large 3D

dataset production on traditional archaeological practice. In contrast to the 'massive' production of 3D models for the preservation of cultural heritage sites, a part of the community of researchers started the development of projects where 3D models were used in different archaeological field investigations in order to evaluate the real impact these data had on the process of knowledge production. Even if these efforts are limited to a few case studies so far, the emergence of such a practice has provided strong indications on: (1) how 3D spatial technologies can be successfully employed in support of any archaeological investigation (from landscape to small artefacts) to provide researchers with diverse descriptions of the archaeological records; (2) how the possibility to review the archaeological record in real time in three-dimensions contributes to such aspects of work as multivocality and democratisation (Berggren et al., 2015); and (3) how the possibility of using 3D models for detecting information otherwise impossible to retrieve, can extensively contribute to the interpretation process (De Reu et al., 2016). Despite their differences, all these experiments have highlighted how the quality of a 3D model is not necessarily defined by the resolution or accuracy provided by the instrument used to digitise the geometrical characteristics of a specific object, but by the efforts of making the model as representative as possible of the characteristics, which the interpreter intended to record and transmit.

3D models and field practice

In the context of the ARKDIS project, several research activities have been conducted with the aim of investigating the production and use of 3D models in support of archaeological practice and knowledge production. Despite the large variety of investigative environments where 3D models can be employed, we decided to focus the scope of our field study on what we consider the most complex environment for what concerns data collection and interpretation: the archaeological excavation.

Differently from many other disciplines where results and hypotheses can be verified multiple times, in archaeology, this practice is not feasible because excavation – a destructive activity by its nature – is the primary method of data acquisition (Barker, 1993). For this reason, the recording system adopted during the field investigation represents a crucial part of archaeological research, and its modification has direct implications on the type of data that will be employed by the archaeologists for interpretation (Dell'Unto, 2014a).

In order to reconstruct the events that characterised the life of an archaeological site, archaeologists expose, interpret and diachronically record contexts and features with the aim of interpreting the evolution of the site by stratigraphy and chronological sequence.

At the end of a field investigation campaign, graphic documentation and site records are the only data available for post–excavation research. For this reason, the recording process must be considered as one of the most delicate parts of a field campaign (Dell'Unto, 2014a), as well as a unique opportunity for observing the materials when still in situ and in their original shape.

One of the first experiments launched for testing the use of 3D models to support archaeological practice was performed on the archaeological site of Uppåkra, Scania, Sweden. Uppåkra is an Iron Age site in Sweden located five kilometres south of the city Lund. The site has been under archaeological investigation since 1996 and the archaeological evidence highlights a continuity of human activities from the Pre-Roman Iron Age until the Viking Age (Larsson, 2007).

The rich and complex stratigraphy and the large variety of structures detected so far (Larsson et al., 2015) make this site an ideal environment for testing new documentation approaches and techniques.

In the last five years (2011 to 2015), several experiments were conducted in order to understand how the introduction of 3D models for mapping the ongoing investigation would affect the site interpretation (Callieri et al., 2011; Dellepiane et al., 2013). Since the beginning, we realised that for operations of field recording, the use of laser scanning techniques was not a suitable solution for creating 3D models in support of the ongoing field interpretation. The time necessary for post processing the raw information prevented the use of the 3D data during the ongoing investigation process. For this reason, we decided to test image-based 3D reconstruction techniques for the daily generation of 3D models of context and features retrieved on site. This technique is based on the employment of mathematical algorithms able to extract 3D dense clouds of points from a sparse group of bi-dimensional pictures (Verhoeven, 2011). Due to their low cost and efficiency in terms of speed and quality, image-based 3D reconstruction techniques recently faced a large diffusion, and are today considered one of the main instruments for 3D recording of cultural heritage sites and materials.

These experiences allowed an understanding of whether the use of 3D models during the investigation campaign increased comprehension of the stratigraphic sequence of the site within the time frame of the investigation (Dell'Unto, 2014b). Three-dimensional models generated with this technique were imported into a three-dimensional geographic information system (3D GIS), which allowed the visualisation of the 3D data in spatial relation with the rest of the documentation generated on site (Figure 3.1).

From this experience, it was clear how 3D models acquired in the field were strongly influenced by the capacity of the archaeologists to perform an acquisition campaign, in which the characteristics of the contexts (as underlined in the field) were properly represented. From these experiments, it was also evident how the generation of 3D models, as a consequence of an intellectual engagement between the material and the interpreter/s, allowed creating 3D data capable of incorporating, in a visual form, elements that were recognised in the field as a result of an interpretation.

An acquisition campaign based on a previous interpretation is capable of displaying a larger amount of information, which can be used during post-excavation activities to support hypotheses and conclusions elaborated in the field, as well as more accurate spatial analysis of the materials. In conducting an acquisition campaign, the photographer takes an active role in the interpretation process and

Figure 3.1 Simulation of part of the excavation sequence performed in Uppåkra (2015–2016). The 3D models imported into the system were used by the archaeologists in support of the interpretation of the materials and contexts.

the result of his/her work will inevitably include and exclude elements that composed the original scene. Particular attention to the role of 3D realistic models in field interpretation was given during the field investigation at the archaeological site of Çatalhöyük, Turkey (2009 to 2015). Çatalhöyük is a Neolithic site located in

Central Turkey, near Çumra in the Konya region. The archaeological investigation is led by Ian Hodder, who started, together with an international group of specialists, the Çatalhöyük research project in 1993. Digital methods have been employed at different stages throughout the history of the project (Tringham & Stevanović, 2012), which became one of the most important examples of integration of digital methods in archaeology (Taylor et al., 2018).

Since 2011, the Çatalhöyük research project employed image-based 3D reconstruction techniques for the documentation of buildings (Forte, 2011), as well as for some of the artefacts and burials (Haddow et al., 2014) detected as a result of field work. Once generated, the 3D models are georeferenced and stored in the Çatalhöyük geodatabase in order to be used in spatial relation to the different types of information recorded on site (Berggren et al., 2015). Due to the complexity of the data recorded by different teams of specialists and field archaeologists, the application of this technique was customised to produce 3D models based on multiple documentation approaches and observation methods. Acquisition campaigns for the identification of change in surface micro morphology have been tested for recording buildings at different stages of investigations, and specific photographic acquisition approaches have been designed by the human remains team to document burials and human material in order to produce models to be used in support of specific observations and analysis (Haddow et al., 2014).

The possibility of using such new types of information for creating 3D archives allowed the researchers of the Çatalhöyük research project to define 3D simulations to contribute to a deeper archaeological understanding of the temporal and spatial relations that were characteristic to the site. An example from the field campaign of 2015 illustrates the possibilities. A plaster head installation was found within Building 132. Due to its instability, the plaster head was removed before it could be studied in spatial relation within the rest of the structure. However, by using the 3D models archive, previously compiled by the team, it was possible to
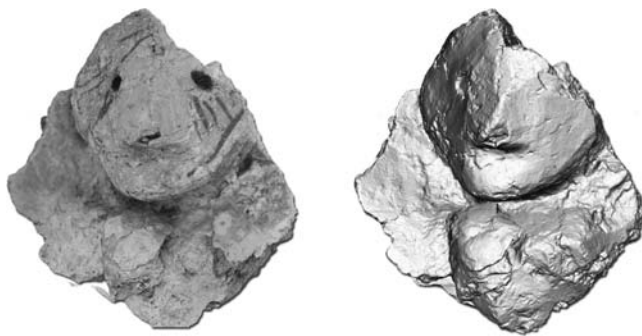
Figure 3.2 Three-dimensional model of the plaster head installation created after the intervention of the conservation team. The 3D model was realised using Agisoft Photoscan 1.2.6. The photographic acquisition campaign was made at the conservation laboratory at Çatalhöyük.

recognise the plaster head in the earlier models when it was still in situ (Klimowicz & Tung, 2015). After the intervention of the conservation team (Lingle & Parkes, 2015), a 3D model of the plaster head installation was created (Figure 3.2) and placed in its original position, in order to be examined in spatial relation to the building (Lingle et al., 2015) (Figure 3.3).

This experience shows how the possibility of accessing an archive of 3D models, systematically generated by direct engagement with the contexts, allowed producing a 3D computer simulation capable of providing crucial information for a more accurate interpretation of the contexts and their spatial and temporal relations.
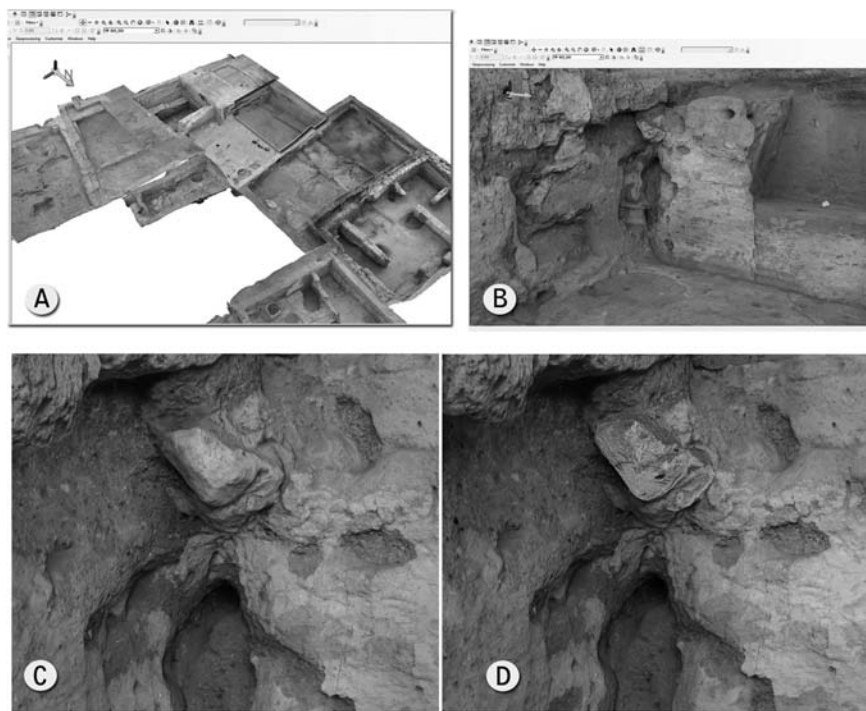
Figure 3.3 Three-dimensional GIS of the north excavation area at Çatalhöyük, which displays a virtual simulation of several buildings, spaces and features documented by image-based 3D reconstruction techniques since 2013 (A). Once aligned, the 3D model of the plaster head installation, created after the intervention of the conservation team, was added as a 3D layer to the system, in order to be visualised in spatial relation with the building (B). Detail of the plaster head (before the intervention of the conservation team) as identified in the 3D model of the building previously realised by the team (C). Detail of the building in spatial relation with the 3D model realised after the intervention of the conservation team (D).

Source: Acquisition campaign and 3D models Jason Quinlan, Marta Perlinska and Nicoló Dell'Unto.

Conclusion

When used in relation to different datasets, three-dimensional data opens new and interesting scenarios for archaeology and provides practitioners with the opportunity to examine information from widely different perspectives. However, the production of 3D datasets needs to be performed first after an intellectual, practical and multi-sensorial engagement with material culture and, most importantly, generation of datasets must be carried out by specialists with a solid training in the subject of archaeology or cultural heritage. The generation of 3D archaeological records without such a foundational understanding and record describing how and why a particular model is produced, could lead to the creation of datasets not sufficiently 'representational' to support future research activities. For this reason, a discussion concerning the real impact of digital data acquisition on archaeological interpretation should be undertaken in parallel with an intense experimentation phase. Three-dimensional models should not be considered solely as a complex and accurate representation of contexts or features that were removed during the field investigation campaign, or destroyed during tragic events, but also as a type of data capable of functioning as a dynamic palimpsest for displaying and combining datasets acquired by different specialists. Three-dimensional models could represent a crucial resource for the future of archaeological and cultural heritage studies, but their creation and diffusion have to be undertaken as a consequence of a solid theoretical and methodological frame developed through discussion among practitioners with different research aims.

New visualisation systems, such as immersive environments and 3D web visualisation tools, could be used in the future to display, not the final interpretations of a site, but the ongoing process that leads to interpretation, providing archaeologists and the general public with the opportunity of relying on visualisation tools capable of supporting different narratives. In creating archives of 3D data that can be used in the future in support of a different narration process, it is crucial to experiment in the use of the data in relation to communication paradigms based on different visualisation methods (Petersson, this volume).

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4 From storing to storytelling – archaeological museums and digitisation

Bodil Petersson (text), in collaboration with Carolina Larsson (illustrations and technical explanations)

A digital turn

In the years 2012 to 2013, several books with the challenging title *The Digital Turn* were published. It can be taken as an indication of how society at this moment in time found the world seriously transforming and changing because of digitisation. The digital was conceived as extending human minds and enhancing our cognitive performance. The digital was also thought of as a tool for merging reality with virtuality (Junge, 2012; Runnel et al., 2013; Westera, 2012). The emphasis concerned how the digital transforms us and how it changes us, as well as our understanding of the world. Digitisation has since shown to be more than a tool, it is a globalising instrument with the power of making stories new and different, and in this sense, digitisation is a world-changing process.

Archaeological museums have adapted to, and started to rely more consequently upon, digital tools for both the managing of collections and display in exhibitions. Today, the tools are available and often affordable even for smaller units. The aspirations within museums are similar to those of libraries and archives. A primary aim has been to make collections accessible with the aid of digital techniques. Several archaeological museums around the world have parts of their collections displayed digitally, one of the most famous being the British Museum, showing around 3.5 million objects in their catalogue online, and it is continuously growing (British Museum website). As a comparison, the Peabody Museum of Archaeology and Anthropology in the US can be mentioned. They also have huge archaeological and anthropological collections and their online collection covers around 300,000 entries (Peabody Museum website). As a comparison in the Nordic area, the Swedish History Museum in Stockholm has an online collection of objects covering around 480,000 entries (Swedish History Museum website). The National Museum of Denmark in Copenhagen has around 108,000 pictures of objects online (National Museum of Denmark Collections Online). The museums have facilitated for visitors the access and use of museum collections in different ways without having to visit the museum itself.

The digital transformation has also changed the approach within museums and their exhibitions and exhibition work (Din & Hecht, 2007; Kalay et al., 2008;

Marty & Jones, 2008; Olesen, 2015; Parry, 2007, 2010; Roussou et al., 2015; van den Akker & Legêne, 2016). With the emergence of tools enhancing interactivity and immersion, the possibilities of changing storytelling in museums are increasing by the day (cf. Simon, 2010). Instead of adapting to a general scheme of doing things in a similar, predictable and traditionally educational manner, a storytelling approach paired with technology has developed prominently in recent years. This has led to aspirations of profiling museums and their digital content as new, modern, immersive, exciting and engaging. It is uniqueness that matters, and the striving within each museum is to find the best way to communicate this uniqueness with an audience.

Approaching the digital

The rapid digitisation of museums evokes questions concerning how the transformation of society into a pervasive digital existence comes into expression in archaeological museum exhibitions.

- What happens with contents and stories in archaeological museums and exhibitions when they are transformed into digital formats of different kinds?
- Are the digital experiences created in museums made for single users or for groups?
- From where does the underlying content acquired in archaeological exhibitions rely on digital techniques? Is there a close connection with museum collections and excavation results, or does today's storytelling in archaeological museums rely on other sources?
- In what sense are the concepts of archaeological information and knowledge production materialising through communication in archaeological museums?

The aim of this chapter is to explicate how digitisation affects presentations of archaeological objects and sites in museums. Is there still a close connection between collections and exhibitions or does the digital turn change the approach and use of collections in exhibitions? Is it fully realistic to build complete, entirely digital worlds using digital techniques? What role do archaeological objects and physical remains of the past have in digitally created environments? Much hope is placed in museum contexts for the use of digital techniques. At the same time, there are perceivable dangers and threats that relate to the practice of archaeology. Archaeology is by tradition a highly material and object-related activity, where authenticity in objects, as well as their existence as physical entities and their appearance, have always been of crucial significance.

Concepts

Within the context of the digital there are several concepts and notions that are used to describe how and with what purpose digital tools are used. Some key

concepts will be explained here to make it easier to understand and follow the discussion in this chapter.

Digital museum. The study here is about uses of digital techniques in museums and exhibitions, not to be confused with the concept of 'digital museums', which mostly means museums that are purely digital and only appear online (cf. Din & Hecht, 2007; Drotner & Schrøder, 2013). In some cases, the lines are blurred though, and traditional archaeological museums use both approaches as they operate both in a physical-based reality and online with digital collections. But as stated in a recent book, it is important to discuss on-site and online museums as different entities. They are completely different from each other, and it is thought that online exhibitions and presentations can help visitors to learn more about a topic either before or after a museum visit. But an online exhibition cannot substitute a visit to a physically based museum (van den Akker, 2016, p. 131).

Interactivity in a strict computational sense means a relation between technique and a human being. A human and a computer interact through a program to solve a specific question. Thereby basic interaction is achieved. However, in a more visionary sense, interactivity in exhibitions is often conceived of as something more elaborate. It is when you as visitor interact with a message conveyed by the exhibition producers. You react upon the message and get to know more, or react differently than you did before relating to the topic presented. The concept *human-computer interaction* (HCI) incorporates these different angles of inter-activity between humans and computers (cf. Kurosu, 2014). However, in colloquial discussion within museums, it is common to refer to 'interactivity' as a means of communicating meaningfully with an audience and thereby make them perceive something new (cf. Falk & Dierking, 2011; Marty, 2008).

Immersion is an often-used concept in the context of museums and exhibitions, and used in such digital techniques as virtual reality. The idea is that the visitor is immersed in an environment that stimulates several senses at a time, so that you feel surrounded by, and immersed into, for example, a specific period of time and/or situation (cf. Griffiths, 2008).

Augmented reality (AR) is a technique where you put visual layers upon existing physical environments or structures with the aid of digital techniques. This can be done, for example, as projections through a handheld device. The point is an enhancement of seeing beyond the existing by putting extra layers on top of reality.

In contrast to AR, *virtual reality* (VR) is a fully constructed environment, not only a layer on top of another layer. There is often a confusion between AR and VR, because, in some situations, the layers of virtual reality are placed on top of photographs or other secondary representations, not on top of reality itself.

Cyber archaeology (CA) emanating from the earlier notion of *virtual archaeology* (VA), is a concept proposed by Maurizio Forte, an archaeologist, who, for a long time, has been working with digital applications in archaeology, especially in the context of research and education. Cyber archaeology is defined as an embodied simulation process engaging the user and creating immersive experiences in cyberspace. It is a virtual action in cyberspace based on interaction (Forte, 2010,

2015, p. 301). In this context, I approach the concept of cyber archaeology to see what development is taking place in digitally created situations.

General aspects

'Museum visits are social events' say Areti Galani and Matthew Chalmers in their text, 'Empowering the remote visitor: supporting social museum experiences among local and remote visitors' (Galani & Chalmers, 2010, p. 156). We shall bear this social approach in mind. Maria Economou has proposed a typology of different information and communication technology (ICT) applications in museums. She puts them into four categories: kiosks, handheld devices, display on the web and VR/immersive 3D (Economou, 2008, p. 137ff.). Inspired by her typology of techniques, I tried to do the same but from the perspective of ten years later.

The outlook has changed since the publication of Economou's text in 2008, especially in the visual and immersive approaches using screens and AR/VR equipment. However, some of her categories are still relevant, even though they partly have developed further into other explicitly screen-based solutions that also enter the category of VR/immersive. As a point of departure, the strategy here is to present museum experiences of today relating to the categories:

- Informative screens
- Handheld devices
- VR/immersive/3D solutions

These three are the main categories that have appeared in museum exhibitions described in this text and studied during the years 2014 to 2017.

As comprehensive evaluations of the developing use of digital technologies in museums are fairly rare, it has been interesting to compare this study with the study made by Maria Economou and Laia Pujol Tost presented in their text 'Educational tool or expensive toy? Evaluating VR evaluation and its relevance for virtual heritage' (Economou & Pujol Tost, 2008). What has happened during these ten years has been that people in general have become increasingly used to both handling and experiencing museum contents in various digital formats (cf. Prensky [2001] and following discussion in Hockly [2011] and Palfrey & Gasser [2008]). Digitally generated texts, pictures, photos and 3D environments are used more intensively than before, in some cases, leaving more traditional text-based presentations behind. Earlier text-based digital presentations were primarily presented in 'kiosks' (Economou, 2008, p. 137f.). The presentation was mainly text-based, even if some pictures and photos tended to appear as illustrations. A kiosk very often comprised of a single computer screen placed in the corner of a museum exhibition room.

Ten years ago, it was feared that technical tools turned serious displays into toy-like gaming experiences or that they were merely expensive toys for the part of the visitor population who were interested in technology

(Economou & Pujol Tost, 2008). Today, the situation is different. Many children throughout the developed world are born and bred with a screen in hand from the very beginning of their lives. The former toy has become a daily tool for everyone. The screen tools, often mobile phones, have even been conceived of as an extra limb and part of our physical bodies (Dingli & Seychell, 2015).

Another concern ten years ago was the visual taking over the world, which would mean that entertainment stepped into exhibitions, and as a consequence, education and information would step out. But this fear has also diminished, as experts have become steadily involved in the development of museum applications and the benefits of catering for different learning styles have been accepted. The transition is still going on and the earlier fears have not entirely vanished, but we are definitely entering a new era of general 'screen acceptance'. It means that our approach to the visual is gradually changing and that we will have to give up some old-fashioned views and fears.

One aspect of the use of digital technologies that unfortunately has not changed since 2008 is that technologies are still very often designed for single users. In general, all members of society have, in a sense, become 'single users', engaged in solitary performances of uploading pictures and text on interactive platforms such as Facebook, Twitter, Instagram and Snapchat in parallel to but seldom together with others. In each occasion, you are a solitary user, merely hoping that someone else will engage with your comments later on. The proliferation of single-user oriented technologies in museums effectively prevents the realisation of a vision of museum visits as social events for groups. Therefore, one of the aims with this text is to explore and propose how technologies can be used in museum exhibitions to retain and enhance a museum visit as a social event.

Examples and themes

The analysis and discussion of digital technical contents and effects in archaeological museums in this chapter is based on study trips to a large number of museums, primarily in Scandinavia. Museums explicitly referred to in the text are:

- The Danish Castle Centre, Vordingborg, Denmark
- Moesgaard Museum, Aarhus, Denmark
- Kongernes Jelling Visitors' Centre, Jelling, Denmark
- 'Medieval Massacre', Swedish History Museum, Stockholm, Sweden
- 'Eye to Eye', Trelleborg Museum, Trelleborg, Sweden
- 'Petroglyfiskt', Österlen Museum, Simrishamn, Sweden
- 'Pompeji', Millesgården, Stockholm, Sweden
- Old Uppsala heritage site and museum, Uppsala, Sweden

Examples have also been collected from other museums whenever they have contributed to the analysis and discussion. The cases are introduced successively because the important aspect of the analysed exhibitions in this text is not where

the museums are situated but which digital technologies they contain, and in relation, how the museum message is constructed and mediated to an audience.

The digital features discussed in this chapter have all been developed after 2010. This means that all the examples are relatively up-to-date and contemporary to each other. It is of possible importance, as technology changes fast. At the same time, the choice of empirical examples was not made because specific new or emerging technologies were used. Instead, the choice was based on the fact that the digital techniques were deployed at the sites by museum professionals as either an interesting or a well-functioning instrument for enhanced communication and display. It would be preferable if this was true in general in the communication of archaeological knowledge, and the tendency would be sustainable enough to be also discussed in the coming years even if technology changed.

The examples are analysed in relation to five themes: *Collections and objects*; *Spatial structures*; *From field to display*; *Immersive storytelling*; and *Informative presentations*. These themes are related to the main questions in this chapter and were chosen to elucidate different approaches to archaeology, knowledge and knowledge relations, display and storytelling. Now, the focus is on these themes and how they can help to explicate museum strategies in the digital age.

Theme 1: Collections and objects

As keepers of objects, traditional archaeological museums usually exhibit artefacts from archaeological excavations. Their magazines are filled with objects waiting for display, but only a few carefully selected objects of the total amount are actually used in exhibitions (cf. Huvila, 2013, p. 1375ff.). Theme 1 specifically addresses examples that clearly approach collections and objects to make these fit into a digitised setting. There are original objects that can only be displayed as original at one museum at a time. Very often, the most attractive and valued objects end up in national museums and thereby the local and regional museums are drained of these objects. With new technologies, as we shall see, it has become easier to display even digitally created objects in a way that makes the them appear authentic in the eyes of the visitor. In a local or national setting, it is perhaps not relevant to talk about 'repatriation', but it is obvious that new techniques make it possible for one single object to appear in several places/exhibitions at the same time (see Stenborg, this volume, for an elaborate discussion on different uses of digital archaeological objects).

One museum that has made use of the material aspects of archaeology, and combined it with the use of digital tools for a more effective display, is the Danish Castle Centre in Vordingborg, southern Denmark (Danish Castle Centre website). The museum re-opened in 2014 and was at the same time reorganised and extended to communicate a general story of Danish castles and forts, not only the history of Vordingborg itself. The merits for doing so specifically in Vordingborg is that in the area there is a huge ruin of a Danish castle, representing the fortification of Denmark against, among other enemies, the Germans for hundreds of years in the medieval period. The only remaining building on spot is the

so-called Goose Tower that was built in the 1360s. On its top stands a golden goose, which according to a story, was placed there by the Danish king Valdemar Atterdag. The reason was that 77 Hanseatic towns had declared war against Denmark in the year 1367, and as mockery, king Valdemar Atterdag put the goose on top of the tower because he said he was as afraid of the Hanseatic towns' threat as of 77 cackling geese.

Today, at 650 years of age, the tower still stands at its original height. In the tower, the museum has placed an exhibition on different floors and when a visitor enters the top floor, there is a screen projection showing how a siege of a castle might have looked like in the Middle Ages. The siege starts with the (digital) destruction of the tower wall, and through the hole in the wall, the visitor can look out over the surrounding landscape and at an ongoing battle around Vordingborg castle (Figure 4.1). The experience here in the Goose Tower is both fact-based with instructive texts and immersive at the same time. Visitors get the story told via text with instructive pictures in between, while seeing moving images of the siege, and the hole in the wall conveys a sense of reality. It is very simply made up using one single picture with moving shots of trebuchets. Between the battle scenes, some aspects of the military technology used in the siege are described, such as the functioning of trebuchet, the use of assault ladders and soldiers and their equipment. Visuality is fully exploited here, not too much text, and instead, a row of pictures showing the main structures and messages. There is no overload of information, just a linear story being told about war, siege and equipment. Of course, other stories could be told as well, and they are, but in other parts of the museum.

The present main museum building of the Danish Castle Centre was built for re-opening in 2014. The new exhibition has been digitised and the museum exhibition now relies completely on the use of handheld devices attached with earphones. This is the case both indoors and outdoors, as the museum display is not limited to the museum building but actually takes the visitor outside. Inside, the exhibition mainly focuses on objects and their inherent stories that are told

Figure 4.1 At the Castle Centre in Vordingborg, Denmark, inside the Goose Tower, there is a projection on the wall with an ongoing battle and information about it from a more technical point of view. Photo: Carolina Larsson 2016.

through handheld devices. Outside, the focus is on the parts of the building that are not standing there anymore, but it is possible to see them standing through the device with the aid of AR, if you hold the device directed towards the locations where the structures would have been standing. Using the application, it is possible to see clearly the outline of buildings that once stood there: walls, houses and a church. With a slightly different technological approach, this could be a really immersive experience, but with the screen-based solution, it is just an informative 3D structure, not aiming to be an immersive experience. To make it truly immersive, specific 3D glasses, at least currently absent from the Danish Castle Centre, would be needed.

Another exhibition with an explicit focus on objects and their display is the *Medieval Massacre* exhibition at the Swedish History Museum in Stockholm, Sweden. In this fairly small exhibition covering three rooms, there are several glass cases displaying objects from a medieval battle in 1361 on the island of Gotland in the Baltic Sea. The battle is iconic in Swedish and Scandinavian history for its cruelty. In the battle, Gotlandic peasants defended the town of Visby against an attack of Danes, but they never received help from the townsfolk inside of the town wall. When the peasants were slaughtered outside of the wall, the inhabitants of the town waited, afterwards, they capitulated to the Danes. This was seen as a betrayal of the loyal men from the countryside.

In the exhibition, the equipment of the fighting soldiers is displayed, and on screens, it is possible to get in-depth information on specific objects shown in the exhibition. This is a fairly traditional presentation of objects, combined with storytelling relating to some of the content, where personal stories, presented from eyewitness perspective, are built around some of the objects (Figure 4.2).

A digital solution, based on visualisation, which might enhance the under-standing of objects in glass cases, are a series of animations showing how a selection of injuries found on human bones retrieved from the battle site occurred. Movements of actors playing the participants of the battle were recorded using motion capture and used as the basis of animations that show the fight and the occurrence of the injuries. Without blood and screaming, these animations are effectively showing the horrors of warfare and battlefields. Combined with the cruel story of how the citizens in the town of Visby did not come to help, it is a fact-based presentation of past materiality that still evokes feelings (Figure 4.3).

In the exhibition, *Kongernes Jelling* in Jutland, western Denmark, it is made possible for the visitor to meet up with objects that are not present physically in the exhibition as original objects but instead represented through a 3D display technique called 'Pepper's ghost'. This is an old technique that has become popular in exhibitions in recent years. Sometimes, the technique is also called a 'hologram'. Today, it is often realised using a projector or a screen that projects a picture on a transparent plate at a $45°$ angle. An object is placed behind the transparent plate and is illuminated. By directing the light from the projection and the light illuminating the object itself, it is possible to choose to show either the object, or the projection, or both at the same time. This makes it possible to show,

Figure 4.2 In the exhibition, Medieval Massacre, at the Historical Museum in Stockholm, Sweden, there is a projection of the battle on one of the walls, accompanied by a surround sound experience. Photo: ©Presentationsdesign.

for example, a fragmented object and then through projection enhance the object so it looks as if it was complete. In the exhibition, *Kongernes Jelling*, it is possible to get close to a famous object, the Jelling beaker, and through this kind of display, you get a detailed view of the object and engage with an explanatory story even if the original object is in the National Museum of Denmark in Copenhagen (Figure 4.4).

Also in Trelleborg Museum, southern Sweden, in the exhibition *Eye to Eye*, the Pepper's ghost technique has been used. An object that can be turned upside down is displayed in the exhibition using the technique, making it possible to show two different faces of a human. The narrative here is limited, but the approach shows that Pepper's ghost is an interesting method of displaying objects in an exhibition using 3D to bring fore several different stories or facets related to them.

It is obvious that new techniques make it possible to enhance the experience of solitary objects within an exhibition without writing lengthy texts about each object in a way that can be disturbing in the visual milieu of the museum exhibition. In the case of the Danish Castle Centre, the experience of the objects is individual. Visitors are accompanied by a voice telling stories through ear-phones making discussion with friends difficult. In a more traditional display based on digital screens and descriptions of objects such as the one in the Medieval Massacre exhibition, it is possible to talk with friends within the exhibition, but
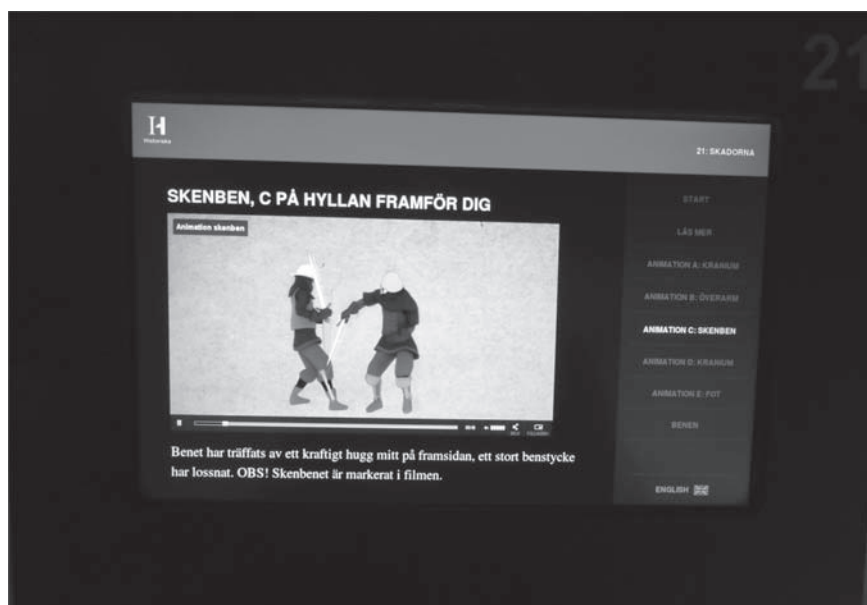
Figure 4.3 In the Medieval Massacre exhibition, the bones with visible injuries are displayed in a glass case next to the screen animations, which show how the injuries happened. Photo: Carolina Larsson 2016.

Figure 4.4 At the *Kongernes Jelling* exhibition, Denmark, the 'Pepper's ghost' technique is used to show a small silver beaker and stories around it; the original is exhibited in Copenhagen. Photo: Carolina Larsson 2016.

in that particular exhibition, the experience was otherwise highly traditional with several lengthy texts to read. After focusing on this first theme of collections and objects, it is now time for the second theme concerning spatial structures that form the surroundings of objects.

Theme 2: Spatial structures

Because of the often-rudimentary character of the evidence of standing structures, not least in Scandinavia, these structures and buildings need thorough description to become understandable for non-experts. With the aid of digital techniques, it is now possible to outline and describe these structures in a physical way. Even if you cannot touch the structures, it is possible to reconstruct them in full-scale and use 3D displays to make it understandable how large, high and elaborate a particular building might have been in the past. This is one of the possibilities offered by digital technologies that have won huge appreciation in recent years. It can be used indoors or outdoors, with or without 3D glasses, to reveal to an audience how a particular set of structures looked like. At the very beginning of 'digital archaeology', it was exactly this very possibility of showing colleagues and non-experts how structures might have looked like and how they were used in the past that fascinated archaeologists the most. A cavalcade of early examples of this can be found in the now 20-year-old book edited by Maurizio Forte and Alberto Siliotti entitled *Virtual Archaeology – Great Discoveries Brought to Life Through Virtual Reality* (Forte & Siliotti, 1997). In the book, a number of, from our contemporary perspective, quite simple but for its time, probably excitingly complete structures emerge in colourful images. What has happened during these 20 years is that the use of 3D has become more common as a part of archaeological practice. Today, almost anyone can experience complete virtual reconstructions live, and reconstructions like these can be found in a large number of museums worldwide.

At the outdoor digital display of the Danish Castle Centre in Vordingborg, the museum has made use of the possibility of displaying structures such as former buildings in the area from the era when the castle was in use. It is possible to walk around the outdoor area, inside and outside the castle and the castle yard, and see for example, the entrance tower, the castle church and the castle hall building. All structures, including walls, roofs and window and door openings are displayed in grey on an iPad screen in 3D. It is possible to walk around and see these structures appear *in situ* on the screen as a user holds it up in the direction of the lost buildings. If a visitor is used to more photorealistic visualisations, this way of presenting as grey shadows might be a disappointment, but still it gives an impression of the height and extension of former buildings in the area.

Compared with the grey structures at the Danish Castle Centre, the structures of the reconstruction of a Pompeian house, the house of Caecilius Iucundus displayed in 3D at an exhibition in Millesgården, Stockholm, Sweden, in 2014 and 2015, were more elaborate and colourful. Here, the full capacity of colour, movement in rooms and interior design has been used to display present-day knowledge of this specific house. The aim of the presentation was not a full visualisation of life in Pompeii, instead, the focus was on architecture and interior design. The difference here is that the reconstructions appear elsewhere than at the specific site, the display in this case is moved to a museum in another country. In Pompeii, several teams from different countries around the world are working with excavations, and this is one of the reasons why the site appears in a large number of digital presentations outside of Italy (Swedish Pompeii project website). It is also easy to get access to reconstructions of Pompeian locations on the web, for example on YouTube, where several reconstructions of areas within the town of Pompeii can be found. This case also shows how the technique of re-creating spatial structures is a tool for the internationalisation of 3D communication of archaeological sites.

As the above examples demonstrate, it is possible to choose a level of digital reconstruction for archaeological sites with disappeared or ruined buildings. In most cases, the choices are based on current knowledge of archaeologists of the structures and their details, and, for example, colours and interior design. In the case of Pompeii, the site is obviously better known than, for instance, the castle of Vordingborg. However, because there are standing castles in Scandinavia, it would have been possible to use them as a basis for deciding how to visualise details. Therefore, the choice of displaying grey structures in a minimalistic manner can also have to do with technical capacity and costs.

After elucidating these different approaches to displaying spatial structures, we have now come to the third theme, relating to the connection between archaeology in the field and the display in a museum setting. Here, we are moved from an archaeological field situation and very often taken into a building where stories from the field are told. But we increasingly see examples of technologies that work in the field as well, so that the sites are not necessarily moved inside museums but can be displayed and mediated directly in field.

Theme 3: From field to display

Whenever the aim is to use digital presentation techniques to communicate actual digital archaeological field data, it would be highly useful that field documentation is conducted digitally from the beginning and that a seamless workflow will be developed to transfer and translate the field data for display purposes. There are still relatively few examples of continuous processes that span from digital recording and display from the field to an exhibition (cf. Vatanen et al. [2010] where they do follow the path from field to display). But according to this study and relating to the chapter on the development of 3D models from archaeological excavations (Dell'Unto, this volume), we are coming close to making it happen.

Illustrative of the ambition to follow the line from field to exhibition is the earlier mentioned, reconstructed Pompeian house of Caecilius Iucundus presented at the Millesgården museum in Stockholm. The groundwork was based on a 3D scan of the structures on site that was used to build a reconstruction as vivid and true to the researchers' interpretations as possible, without an ambition to add anything that was not there. The argument of the researchers is that a visualisation such as this of a Pompeian house, is also expected to help researchers in the interpretation process. They are not made merely for communicating the findings with a general audience but evidently also to help in the research process (The Swedish Pompeii project website; Dell'Unto et al., 2015).

Another example that connects field archaeology and digital presentation is from Sweden. Old Uppsala in central Sweden is a major archaeological site dating from the period when this area was turning from heathendom to Christianity. In recent years, there have been several excavations that have uncovered new aspects of this transition period in early Scandinavian history. Results of the excavations have been used to create a virtual world that gives on-site visitors the possibility of experiencing the environment in a simulation using an approach that can be described as a hybrid of augmented reality and virtual reality. Visitors can access an interpretation of how the area looked like in the Iron Age, using a screen of a portable device. This is an outdoor presentation of the past, whereas the Pompeii example described above, was clearly designed primarily as an indoor presentation (Disir Productions website).

In both the Pompeii and the Old Uppsala cases, the archaeologists engaged with a vision of how to display the past in the stage of interpretation and presentation to the public while conducting original fieldwork. They have been working with this vision from start and are therefore able to produce digital data and material created with a specific public display situation in mind. Consequently, in these cases, the archaeologists have not worked from the premises of a general archaeological standard of scientific documentation, but have incorporated in their work a specific point of view, the idea of communicating the results of the investigation. For archaeological communities, this approach can be crucial for success in the long run. It is necessary to adapt to the fact that out there is an audience expecting interpretations to be communicated in a format and on

platforms that are a part of their everyday information habits and behaviours. Most communication today does not emanate from initiatives already taken in archaeological field situations, except from specific research projects with explicit aims to communicate results. This approach is rather unique, but the emergence of projects taking communication into account already in the field is growing. One such example is the IDA system (Instant field Documentation system and Availability), currently developed in the context of Swedish contract archaeology. The premise of IDA is to consider outreach and communication of archaeological recordings already in the field (Kalmar County Museum website).

Another way of outreach, which is often used today, is to develop from fact-based information to immersive storytelling involving all the senses. It is now time to consider the fourth theme, which concerns aspects of immersive experiences in digital settings in museums.

Theme 4: Immersive storytelling

One engaging way of displaying the past with digital techniques is by using it to perform immersive storytelling. Here it is obvious that traditional skills of museums staff are used together with various digital techniques. The main premise of the approach is to create a story around the case and to transform it into digital formats involving more senses, and with some kind of interactive ingredients present as well.

At Österlen Museum in southern Sweden, the temporary exhibition, *Petroglyfiskt*, was shown during the years 2013 and 2014 (Ljungar-Chapelon, 2015, 2017; Petersson, 2014). The exhibition had a special focus on the Bronze Age and its mythological aspects as represented through rock carvings and decorative elements on bronze objects. In the area of Kivik, there is a stone cairn, 'Kiviksgraven', with carvings on stone slabs that once formed the grave of one or more individuals in the Bronze Age. The motifs represent ritual acts, objects and processions. One of the immersive techniques used was based on real-time motion capture. A camera was installed in the exhibition space and it was used to detect the movements of the visitors. The motions were used to control the movements of a digital character in a digital setting to make the visitors a part of a story that was displayed on a screen. By engaging with the application, visitors could participate in a Bronze Age funeral procession, where a recently deceased person was being transformed into another existence with the help of living individuals performing a procession (Figure 4.5). The technique only allows one person at a time to enter a room where your movements are detected and projected on a screen together with the rest of the procession. The movements of the procession are interpreted in an artistic way and cannot be said to have an explicitly fact-based connection to how it really was in the Bronze Age. It is a solitary experience, but you can have other people standing by you when you perform a dance or move yourself as a part of the procession. In this case, being alone when dancing might have been comfortable for visitors, as it might

Figure 4.5 Österlen Museum created a motion capture experience that made it possible for the visitor to experience a dance with petroglyphs appearing on stone slags in a nearby Bronze Age grave cairn. Photo: Jes Wienberg 2014.

feel somewhat awkward to make these movements in front of other museum visitors just passing. The experience is based on an interaction between the visitor and the technique, it is not intended for groups. The experience conveyed by the application is related to a grave field in the vicinity. There are rock carvings found in an inner part of the grave cist, where stone slabs have been decorated with a drawing of a procession. The application transformed this specific procession into an interactive experience in the museum. Visitors could visit the actual site in the landscape outside the museum, either before or after the digital experience (Ljungar-Chapelon, 2015, 2017).

Another immersive experience in this exhibition was a storytelling room where visitors sat in a group on a soft mat in a small room, with projections on three walls that created a 3D experience (Figure 4.6). With a story about the Bronze Age cosmology, the visitors plunged into the mysterious world of the period and its cosmology as depicted on razor knives dating from the period. These motives from the Bronze Age are used to present a story of the sun and its travel across heaven in daytime and under the sea during the night, to rise again the next morning. The story is based on archaeological research, with a special focus on the interpretations made by the Danish researcher Flemming Kaul, who has analysed the motives of these knives thoroughly (Kaul, 1998).

Figure 4.6 Österlen Museum also provided a storytelling room with soft mats on the floor, where you could sit to watch and listen to stories relating to Bronze Age cosmology and sun worship. Photo: Jes Wienberg 2014.

Storytelling and the Bronze Age are easy to connect, as there are many pictures from the period with humans and animals both within rock art and on objects from the period that obviously represent aspects of life and belief in this period of time. Another exhibition, at Moesgaard Museum in Denmark, has an interactive component relating to this period as well. At this exhibition, a visitor can sit in the audience as a stick figure appears in the ceiling as a rock carving, it represents a storyteller from the stars, and you listen to a voice that tells you about the beliefs of the period at the same time as the night sky with stars is displayed. When the stories are told, a visitor sees different moving images drawn in a simple fashion to represent rock carvings depicting mythological themes (Figure 4.7). Here, the visitors can take part in the story as a group of several people, with no motion capture involved. Participating in this experience can therefore be a group experience as well as a solitary one.

The *Kongernes Jelling* site museum in Denmark is located close to the World Heritage Site of Jelling in central Jutland (Unesco World Heritage/Jelling website). The Scandinavian Viking Age is a period that has left behind an abundant storytelling tradition passed on in written sources, especially from the medieval period, but also rich archaeological findings throughout Scandinavia

Figure 4.7 At Moesgaard Museum, Denmark, the Bronze Age theme with storytelling and
cosmology also appeared, this time with the aid of projections close to the
ceiling, where a simulated starry sky was made as a backdrop for the stories and
projections of typical Bronze Age symbols. Photo: Carolina Larsson 2016.

and a large amount of rune stones that tell stories about the inhabitants of the Nordic
region in this period. At the specific site of Jelling, huge excavation campaigns have
been conducted in recent years. The past topography of the site has been recon-
structed and visualised in the landscape around the museum (Kongernes Jelling
website; the Jelling project website). The era reconstructed in Jelling is that of Harald
Bluetooth, the king who united Denmark and Norway and Christianised the Danes,
a story that is told in a huge inscribed rune stone standing close to the museum, as part
of the World Heritage site. When the visitors enter the museum exhibition, they can
sit in large groups around a fireplace in a dark Viking hall, and listen and watch
illustrated stories while sitting by fire and flames. The show is a mix of mythology and
real events, which is very often the case with the Scandinavian Viking Age and how
it is displayed in museums. After the storytelling in the darkness around the fireplace,
visitors enter the museum that has more background information and communicates
archaeological knowledge of this World Heritage site. From a visitor's perspective, it
is an immensely effective immersion that takes place at the very beginning of the
exhibition. Through this experience, the visitor gets motivated to take part in the rest
of the exhibition. The experience is made for groups. Even large bus groups can
be placed together around the fireplace and the technique used to convey the
experience does not hamper the possibility of experiencing the museum as a group.

Figure 4.8 At the museum, *Kongernes Jelling*, the visitor could go to Valhalla with the aid of motion capture. Photo: © The National Museum of Denmark.

At *Kongernes Jelling*, they have also made use of motion capture, as you move along a line inside a ship setting, a sketch on the floor in one of the rooms of the museum is said to be the warrior's journey to Valhalla. During this journey, you can see yourself in a mirror being transformed from 'life' to 'death', represented by transformations through ice and fire during the short walk through the ship setting. The shift relates in parallel to how a Viking warrior moves from death to the afterlife. In the presentation, you take the place of the Viking warrior and get transformed as you move. The approach is almost identical to the one in Österlen Museum. The visitor is alone but can be joined by a smaller audience (Figure 4.8). The active visitors see their movements transformed in a projection in front of them, as a camera detects their movements along a straight line marked in the floor.

This is an individual action, but it is possible to be accompanied by an audience, in most cases, probably the group the visitor is with, while the rest of the group is waiting to access the experience. Moving successfully also requires someone to instruct the visitors on how to move, and for this purpose, the museum has a person helping the groups in this part of the exhibition. It is therefore also a group experience, but only with one active participant at a time. The rest are expected to stand watching this one person taking the steps through ice and fire.

Another strategy had been chosen at Moesgaard Museum. A battlefield experience was placed in an exhibition room relating to the Iron Age. Here, the visitors enter the centre of a battlefield. They are placed between two advancing armies surrounded by the sight and sound of the groups approaching and eventually engaging and killing each other. It is an immersive experience, and it

Figure 4.9 At Moesgaard Museum, Denmark, in the Iron Age exhibition, you are in one of the rooms surrounded by screens and suddenly you appear in the middle of an Iron Age battle, with both sights and sounds. Photo: Carolina Larsson 2016.

is possible to either stand alone or in a group on this spot in the middle of the battlefield and experience the sights and sounds of the battle (Figure 4.9). Before or after this experience, it is possible to see cases and boxes in the walls and floors of the display room, as well as glass cases in surrounding rooms where artefacts from an excavation are displayed.

At Trelleborg Museum, as a part of the Stone Age exhibition, *Eye to Eye*, there are animals of the Stone Age as a magic display on a wall. It is a fairly traditional moving images technique. The point here is how the moving animals change shape into each other's contours. The moving images share the Stone Age shamanistic view of nature with the museum visitor. This visual experience does, in a very simple way, convey a feeling for Stone Age animal life, and instead of being based on stuffed or reconstructed animals and skeletons, the movement in this projection-based technique of exhibiting animals comes close to the style of storytelling about humans and their relationship to the animals of their time.

As the examples so far seem to suggest, the Bronze Age is an archaeological period apparently well suited for so-called immersive storytelling. It seems that it is the objects, rock art and the general ideological and religious mystique that appeals to storytellers. In Moesgaard Museum, the stars in the sky tell us about cosmology in the Bronze Age. In contrast, in Österlen Museum, the visitors are immersed into the same cosmological world and stories surrounded by projections, which create a 3D environment without specific contours other than the motifs from rock carvings and razor knives of the period.

The situations evoked in immersive storytelling can either be group experiences or solitary experiences. In museums, solitary experiences are sometimes problematic because several people usually tend to go to an exhibition together. Therefore, the use of too many situations demanding individual experiences can prevent people from experiencing the exhibition together. Still, it is perhaps easier with individual experiences at smaller museums and visitor centres, at least when there is no rush with large groups of people entering the museum at the same time.

As a parallel to the development towards more immersive experiences in museums, there is also a discussion among archaeologists on how digital technology changes the archaeologist's approach to the past within archaeology in general. Maurizio Forte comments upon the development within digital archaeology. He remarks that early archaeological models were technologically impressive but focused solely on architectural elements and not on life in the past (Forte, 2015, p. 296). What is definitely seen, at least in the museum exhibitions of today investigated as a part of this study, is a change of approach from representations of the structures of sites and monuments to presentations of human lives and practices relating to these structures. In the past practice of early virtual archaeology, for example, 'almost no human activities were represented in the reconstructions, and very few avatars populated the digital landscapes making the empty models appear to depict an artificial past' (Forte, 2015, p. 296).

Forte is primarily discussing the archaeologists' role in an interpretive process *before* presentation in museum exhibitions. But there is a growing interest among archaeologists using digital techniques from field situations to enter museums

with this information, and therefore it is relevant to how archaeologists approach the digital and how archaeologists can envisage the use of digital tools for explanations of the past in communicative situations. There are obvious differences between archaeologists and museum staff when it comes to storytelling. When archaeologists are involved in reconstruction work in digital formats, the structures or architecture is in focus while human life is left aside. At the same time, museum staff want to add the human aspect to structures and architecture to make the reconstructions come alive.

As exhibition makers put more effort into immersive experiences, they can also pick productions from elsewhere such as wandering exhibitions on topics of interest to a broader audience. We came across exactly this when visiting Moesgaard Museum. It was an interesting example of a museum experience where the structures were filled with human avatars acting on a stage, among other elements. This was part of a virtual construction as the wandering exhibition had the Colosseum on display and the life of the gladiators was the focus of the exhibition. The exhibition combined an immersive part with a full-scale immersive screen display in a large room, and adjacent to the screen display there was a traditional exhibition with glass cases with objects from the period and location. This wandering exhibition also represents the possibility of moving the whole environments from one country to another to make people in other parts of the world get immersed into a site in virtual reality or through projections. The visitors are invited to meet the people of the past. Instead of putting the Colosseum itself in focus, the main story was composed to narrate the daily life of the amphitheatre. This shift of perspective is a paradigmatic change when compared with traditional exhibitions. A comparable change is taking place at some museums today, but not yet in general in the minds of archaeologists, who feel more comfortable with fact-based, non-immersive explanations. Here, a synchronising effort is needed, as archaeologists are educated to present results from archaeological excavations either scientifically or with a popular scientific approach and museum staff are educated to make use of immersive storytelling to engage different kinds of audiences.

The exhibition makers describe the project as follows:

> In the Colosseum exhibition, traditional methods of presentation such as displaying of original objects were combined to modern replicas based on rigorous scientific documentation, cutting-edge interactive technology, suggestive graphics and other multimedia devices and applications. Featuring a spectacular set design, the exhibition unfolds on two paths revealing two protagonists, interwoven by destiny: the gladiators and the Colosseum, that colossal, complex structure that was the stage upon which their fate was determined.
>
> (*Contemporanea Progetti* website)

As the exhibition makers note, the two paths are interwoven by destiny, and it is also possible to see the archaeologists and exhibitions makers as interwoven by

destiny to merge tradition and cutting-edge techniques as well as scientific and storytelling approaches.

Actually, Forte puts his finger on what seems to be difficult for archaeologists. Often, an archaeologist wants to preserve standards and control over the archaeological process, at the same time as there are demands that the process should be open, multivocal and transparent (Forte, 2015, p. 298). At least Forte believes in making the process more transparent. He adds: 'the more impressive and photorealistic the model is, the more difficult it is to validate it or to offer alternative interpretations of the initial data' (Forte, 2015, p. 298). If we return to the approach of the Colosseum exhibition to create life and action in an architectonic structure, it is definitely the case that they have tried to be impressively photorealistic, and that the main focus of the effort here is not to start discussion but a communication of how, at this stage of knowledge, the life of the gladiators might have been (Figure 4.10).

As Forte points out, photorealism makes exhibited objects and structures look so true that it is difficult to ask questions about them. If we instead turn to the greyish structures of the castle in Vordingborg, Denmark, the structures evoke questions when visitors realise that they are not watching an interpretation that will be standing there forever. However, as the aim of immersive storytelling is to immerse, the strategies are different from each other because of that as well.

There is, as seen in the discussion above, an existing divide between immersion and information, a divide that is partly visible also between museum staff and (field) archaeologists. Therefore, a discussion is needed that, in practice, will also bridge the gap between field archaeology and museum exhibition makers, be

Figure 4.10 At the Colosseum exhibition, they had a 3D display where you could experience life in the theatre. Photo: Carolina Larsson 2016.

they archaeologists or not. We now come to the fifth theme, where focus is on displays containing information in a more traditional and educational manner.

Theme 5: Informative presentations

Of course, museums do still rely upon structures that inform visitors about the exhibitions and results from archaeological investigations in words. This information cannot always be conveyed in an immersive manner. Thus, there are also structures supporting traditional educational approaches to archaeology.

   The main attraction at Österlen Museum was naturally the 'Dances with Petroglyphs' experience described above (see also Petersson [2014] for a more elaborate description of this specific museum experience). But having said this, the museum did not totally forget about the people who were seeking facts about the Bronze Age. Attached with the tantalising name 'wishing well', another display at the fairly small exhibition made it possible to look into exact information on objects and sites from the Bronze Age, and to learn more about the past using a touch screen on a horizontal table. Text-based information and illustrations were combined as all of the texts were accompanied by photos, drawings and maps (Figure 4.11).

Figure 4.11 At Österlen Museum, there was a traditional method of fact display in the form of a 'wishing well', where you could find out things about the Bronze Age period and different aspects of it. Photo: Bodil Petersson 2013.

At Moesgaard Museum, the approach was different and more personal. As in other, more informative exhibiting strategies, screens play a vital part. But in this case, the screens show people, for example, researchers or museum staff, standing there, waiting for someone to come close and push a button and start talking to them (Figure 4.12). Then they start telling a story from their own specific area of knowledge, be it Bronze Age offerings in bogs or Iron Age battles. Even if the recordings are already made, there is a sense of presence via the screen that enhances the effect of the experience. The informative approach is also added to by the abundance of objects displayed in glass cases in the Moesgaard exhibitions in general.

The Danish Castle Centre is marketing itself as a digital experience centre. One main reason of using digital techniques in an exhibition is to tell facts about objects in showcases. Instead of exhibiting enormous amounts of objects that overwhelm the visitor by their sheer number, the strategy in Vordingborg is to present unique objects and their individual stories, almost as if the objects were individual beings. One specific object that I was fascinated with was a worn textile fragment. I usually find these kinds of fragments rather boring, as they are often presented as textile of a special kind, woven using a specific, meticulously named technique, mentioning that it is probably a part of a dress, sail or something else. But because here the story was told of a fragment that was quite small, ugly and uninteresting to look at, it did actually make me linger and listen to it. The immersive experience here is not that you become overwhelmed by a unique technological approach, it is instead the fact that you are alone with each object and its story is being told exclusively to you. To start with, the technical equipment felt a bit heavy around the neck, and the cables between the earphones and the device got entangled in my dress, but if the visitor overcame this, it was a fascinating experience, with simple, fact-based stories of objects, their relation to a living society and the effort to make them come to life once again (Figure 4.13).

In the *Kongernes Jelling* exhibition, the visitor sees an informative presentation on a wall projection and interacts with a screen on the wall to get more know-ledge about the famous rune stone erected by Harald Bluetooth (Figure 4.14A). In Jelling, it was possible to participate together as a group and engage with informative descriptions and projections. Because the original stone is now hidden behind glass as a result of a case of vandalism some years ago, the digital opportunity to encounter the stone can be seen as a technically assisted approach to let people come closer to the stone (Figure 4.14B).

In the *Eye to Eye* exhibition of Trelleborg Museum, the exhibitors created an interactive screen where a visitor could make facial reconstructions of the ancient Stone Age settlers of the hunter–gatherer site of Skateholm nearby Trelleborg. The solution is a typical interactive application, with a free choice of 'designing' humans, with hair, eye and skin colour. But because the basis of the recon-structions are the craniums found during excavations in the 1980s, the visitors use archaeological results to re-build the inhabitants' visual appearance. This appli-cation parallels with the fascination among archaeologists for facial reconstruc-tions, both computer based or made in wax, often for display in museum exhibitions (O. D. Nilsson Sculptor's Studio website). In Sweden, for example,

Figure 4.12 Bronze Age expert Flemming Kaul greets visitors at the Moesgaard Museum Bronze Age exhibition via a screen where he (and other researchers and museum staff) meets the visitor eye to eye and starts speaking when the screen text is touched below him. Photo: Carolina Larsson 2016.

Figure 4.13 In the outdoor environment surrounding the Danish Castle Centre, Denmark, a visitor could walk among ruins and point a device towards them to see the buildings appear in full scale. Photo: Carolina Larsson 2016.

Figure 4.14 Jelling rune stone projection inside the Kongernes Jelling Museum (A), and the original stone in its outdoor glass case on the church yard next to the museum (B). Photo: Carolina Larsson and Bodil Petersson respectively, 2016.

there has been great interest in building faces of archaeologically well-known humans and making copies of them to put in museums, the very latest example displayed in a recently opened Viking exhibition in Stockholm, Sweden, called the 'DNA-copy' of a Viking, made by O. D. Nilsson (Figure 4.15A).

Figure 4.15 Facial reconstructions in wax of Vikings from (A) Stockholm and (B) Trelleborg, both in Sweden. Photo: 15A ©Vikingaliv and 15B ©Trelleborgs Museum.

This screen-based facial reconstruction can be seen as similar, but at the same time, the choice and thereby the discussion concerning visual appearance is more explicit than when you get the full reconstruction that is already interpreted. A traditional facial reconstruction of a Viking male person with specific traits such as furrows in his teeth is also displayed in Trelleborg Museum (Figure 4.15B).

What then are the ingredients when it comes to fact-based storytelling? First and foremost, it is of course that there actually are facts to make use of in the storytelling. This is often true with later archaeological periods, in a Scandinavian context, mostly the Viking Age and the Middle Ages, when there are written sources available to complete the rich archaeological sources.

Examples of fact-based storytelling are the text screens in the exhibition on the *Medieval Massacre*, Stockholm. Here they are used to communicate both eye witness stories and historical descriptions. Hence, one source of confusion in the exhibition was that 'I'-stories told by 'participants' of the battle were presented together with the factual content. The problem with these stories was that they were not from the time of the event but were instead created by the producers of the exhibition (the Swedish History Museum website).

An example with a digital projection on a rune stone in *Kongernes Jelling* shows a way to get the audience closer to an object that might be hidden behind glass. A parallel, but in a larger scale, is the Lascaux cave painting experience, where a full-scale model of the cave has been reconstructed so the original will not be damaged. Interesting with Lascaux is that both a physical replica of the cave and a touring virtual experience have been produced. The digital version has the opportunity to be exported while it, at the same time, remains in place (Kongernes Jelling website; Lascaux website).

When it comes to facial reconstructions, such as the example from Trelleborg Museum *Eye to Eye* exhibition, it is obvious that the possibility of interacting with screens and making choices is a very good example of an advanced interactive application that takes the discussion on human appearance in the past to a new level.

Combining the two ways of reconstructing human appearance, faces made of wax and computer reconstruction, is an effective approach of explaining what lies behind interpretations. With recent DNA developments relating to archaeological finds of humans, it will be possible to take this interaction even further.

Now it is time to return to the questions posed in the beginning of this chapter. They were on the topics of content and stories in transformation, solitary users and groups, digital museum contents and its sources and archaeological information and knowledge production in exhibitions.

Contents and stories in transformation

Through the previously mentioned examples, it is clear that content is in transformation in archaeological museum exhibitions, and that the content is turning digital. In a digital exhibition, the focus is changing from seeing objects to participating in the quest for acquiring more knowledge, or alternatively, participating with one's own body and/or senses in an experience based on storytelling. The authentic objects are not marginalised but are put into contexts that make their role in exhibitions less prominent.

Solitary users and groups

There is obviously a tension between the ambition to satisfy individual visitors and users of specific types of devices in museum exhibitions. The solitary user experience is most explicit when you are handed a device with earphones to guide you through the exhibition. Through that strategy, visitors lose connection with their fellow museum visitors. Perhaps, it is possible to reconnect by knocking on their shoulders, but otherwise, the visitors are alone until the end of the exhibition. But there are examples of how digital storytelling can be designed for groups, where the interior, sound and participation can primarily be experienced in groups, such as at the hearth of *Kongernes Jelling* and the battlefield of the Iron Age at Moesgaard Museum. It is obvious that there is a general need for considering and being aware of the solitary or social nature of the designed experiences when exhibitions are planned.

Digital museum contents and its sources

In some cases, it is clear that the museum exhibition has direct connection to an archaeological excavation or a stored archaeological material in a museum collection. In this study, the link between field and display has been closest in the Pompeii and Old Uppsala cases. In both, it is possible to see a clear and continuous connection between the field situation and the archaeological results, and the interpretations presented at an exhibition.

Archaeological information and knowledge production in exhibitions

In general, archaeological museums are working with archaeological information. They also produce knowledge, but that knowledge differs from that

produced at archaeological excavations. The process of exhibiting archaeology is also a process of interpretation. This is not because of its eventual digitality but because it is generally so. I will return to this topic later in the text.

After discussing the possible answers to the questions in this chapter, it is time to broaden perspectives to more general reflections on digital formats as means of displaying archaeological results and interpretations, and to discuss the primacy of the visual, how visual aspects of the past have become emphasised in archaeological museums and exhibitions, because in many cases, digital solutions rely on visual effects.

Digital formats

Digital formats are handled differently depending on what purpose the format has. When it comes to exhibitions, it is obvious that each museum strives towards uniqueness of its displays and how visitors experience their exhibitions. Almost all exhibitions with a digital display have a technical focal point of efforts to transform archaeological results and/or stories into a digital sensory experience.

Examples of the strategies of offering sensory experiences are the dance performance at the *Petroglyfiskt* based on motion capture technology, the walk through ice and fire at *Kongernes Jelling* and the battlefield experience at Moesgaard Museum.

Maurizio Forte expresses that we are now leaving virtual archaeology and entering cyber archaeology, a phase where archaeologists – he is especially talking about archaeologists, not audiences in museums – become more interactive when using digital representations. The archaeologist's perspective provided by Forte explains how archaeologists think about representations and reconstructions of the past and shows the approaches from an archaeologist's point of view. This can then be compared with a museum approach, and ultimately the difference has to be bridged to reach effective museum communication. In Table 4.1, he shows the differences between virtual and cyber archaeologies as perceived by him.

Considering the current state of affairs and the aspects of archaeological practice Forte expects to transform, I think we are not yet there. This is because the interactive and immersive step has not been taken fully, at least not within core archaeology practices. Archaeologists sometimes actually seem to have a serious fear in addressing the human aspects of the past. Archaeologists are clinging to structures and patterns that can be seen in the material past. In an extremely futuristic and in a way hopeful manner, Forte holds forth that cyber archaeology is something completely different from former digital approaches (Forte, 2015, p. 308f.). In a way it might be so, but I would argue that we as humans now, with the aid of new techniques, have found a way to act visually, something that suits us well, because we are visually dependent and competent. Thus, it is the visual rather than the cyber or digital that is the focal question. We can put together (re)presentations of past worlds with more sensory depth and breadth than before, and in doing so, we can more intuitively combine different

Table 4.1 Table from Forte (2015, p. 301) illustrating the differences between virtual archaeology and cyber archaeology according to their specific characteristics and tasks *(Forte, 2015, p. 300f.)*

Virtual archaeology	*Cyber archaeology*
Visualisation process	Simulation process
Basic interaction	Feedback, behaviours, embodiment
Passive users	Content providers
Model engagement	User engagement
Individual environments	Collaborative environments
Desktop	Immersive
Analog to digital	Digital to digital
Models	Enaction/interaction
Computer renderings	Cyberspace
Individual users	Virtual communities
Animations	Real time
Flythrough	Serious games

sources and thereby combine different sensory aspects of the past. The fear of losing the analytical gaze to the past is not a threat, instead, the enhanced visual and multisensory approaches give us a possibility of combing different perspectives by involving more senses to gain more comprehensive insights into past circumstances.

New techniques work in other directions as well. When objects from an excavation are put on display at a national museum, the objects are lost to the local museum. But with the aid of digital technology, the objects can be brought back as digital artefacts to the geographical context where they were uncovered and to the sites of their origin. This has been done, for example, at the *Kongernes Jelling* museum, where the displayed objects are copies and/or enhanced (re)productions in a digital format with the help of projections (more on this topic in Per Stenborg's chapter in this volume).

On visual primacy

Contemporary digital tools come with the possibility of expressing advanced visual interpretations. Until now, the written word has had an unthreatened precedence over visual representation in presentation of archaeological finds, especially within research but also in exhibitions, where objects are followed by explanations in words. But perhaps this is also changing now. The use of multiple senses to process information is part of being human. An empathically multisensory approach would be much needed both in museum exhibitions and in research. It would enhance the possibilities of letting experience and information go in both directions, from research to communication and from communication to research. From this perspective, the chosen communication strategies could play the double role of communicating and returning feedback to the research

community and the archaeologists that once excavated and first interpreted the past at a specific site.

In the book, *Visual Heritage in the Digital Age* (2013), the editors, Eugene Ch'ng, Vincent Gaffney and Henry Chapman, state that 'digital heritage can be said to be approaching a stage of maturity', as they see more complete processes within research that are also paired with more practical methodologies being consolidated in the context of digital heritage in general (Ch'ng et al., 2013, p. 349). This indicates that the ARKDIS project, the context from which this present book emanates, was launched when a certain level of maturity of digital practices in archaeology could already be discerned. At the same time, Ch'ng and colleagues saw this field being democratised as a result of technologies becoming both cheaper and more widespread, and at the same time, as a partial consequence of the possibility of using social media for presenting and discussing heritage with a larger audience. Still, the authors note signs of disorientation (Ch'ng et al., 2013, p. 358f.). They put emphasis on visualisation tools as tools for research in addition to being mere tools of communication. Fundamental to the digital development is that visualisation is seen as an essential tool for both communication and research (Ch'ng et al., 2013, p. 356f.). They have chosen to illustrate this (Ch'ng et al., 2013, Fig. 18.1) and this figure shows explicitly the expectations of the approach that the visual is also important for researchers, and that the visualisation process within communication efforts also gives feedback to researchers even after communication is being made to a general audience (Figure 4.16). This can, of course, be done using social media, but also with museum exhibitions. Hereby, visualisations and even museum exhibitions cannot be seen as end products anymore.

The visual aspect holds important but still not enough valued tools for research, interpretation and communication at the same time. Communication gives, or can give, essential feedback to researchers. When is the digital development mature enough to take care of this feedback system in a serious way? Most lines of research end with communication, but the communication is seldom seen as essential underpinning for research. Moving in a direction that would bring the two closer together would be a major change and challenge for the future and a general outcome of digitisation. Projects such as the Swedish Pompeii Project and the Old Uppsala AR application, as well as *Petroglyphic*, give indications of the possibilities of providing feedback to researchers, even if such a paradigm shift is currently a distant one, as not all researchers understand the research value of digital visualisations in museum exhibitions.

Interestingly, as Dell'Unto mentions in his text in this book, researchers of the future could interact with the past in 3D models, get multisensorial impressions and thereby obtain other kinds of multisensorial knowledge relating to the past in an alternative kind of a setting. Here, certain similarities can be seen with the situation in museums, with the difference that knowledge production in these two contexts has different aims. In Dell'Unto's case, its target group is researchers, and in museums, the 'audience' of knowledge is the public. At the same time, we can see how 3D models created for research can be used directly in exhibitions,
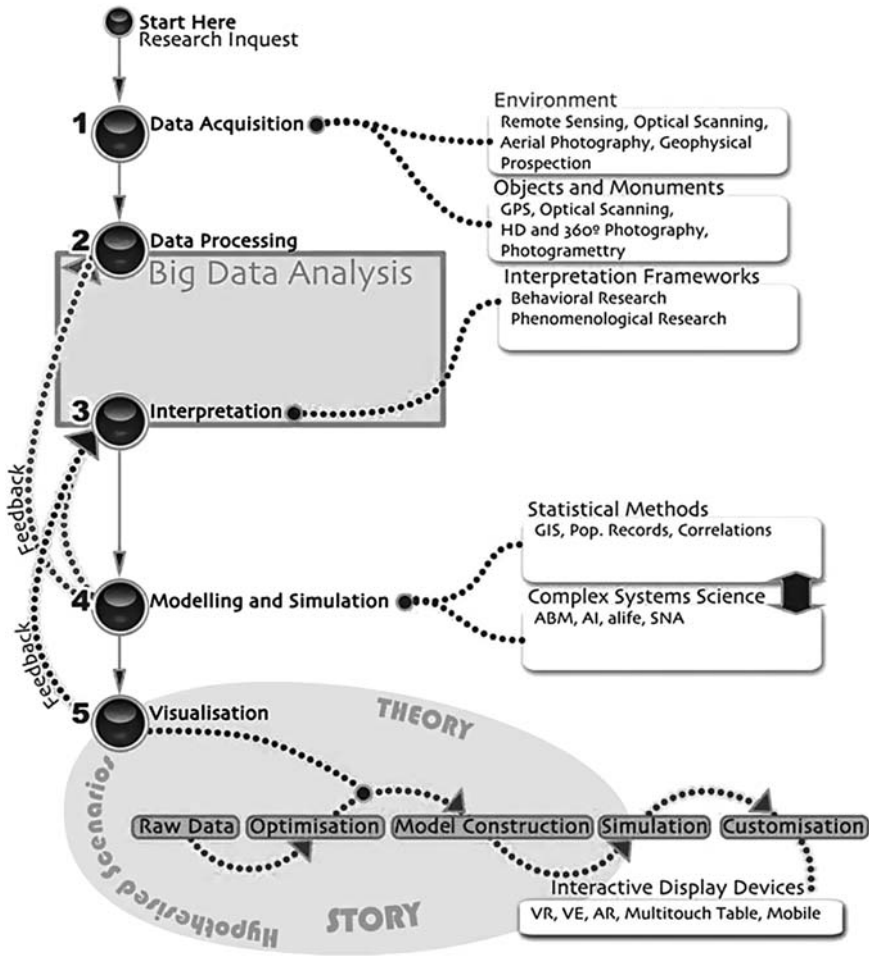
Figure 4.16 'The research process road map within heritage and archaeology' (Ch'ng et al., 2013, p. 353; text relating to Fig. 18.1 is used here).

even if other sets of steps are needed for an archaeological 3D trench to a reconstruction model if the aim is to make archaeological research and interpretation visual and possible to understand for a broader audience.

Archaeological information and knowledge production in museum exhibitions

Given that archaeological exhibitions are based on archaeological materials and excavation results, exhibitions are turning from an informative mode into another, more experiential one. The involvement of multiple senses in the interpretation

process enhances our ability to understand things in different ways. In the context of museum exhibitions, there is always an element of knowledge co-production. The input that emanates from the exhibitors is processed in the minds of the visitors, and the outcome can be enhanced understanding, knowledge or an enriched experience of the past. Learning in exhibitions has been transformed during the past few years and this has had a major impact on the understanding of how knowledge is transferred from experts to the general public and back again. Communication is moving in different directions, and learning is possible in both groups at the same time, for experts as well as for the general public.

Between storing and storytelling

The role of archaeological museums is often perceived to be to take care of excavated objects and structures, to store them carefully and to use them to communicate knowledge, understanding and experiences relating to these objects. Techniques offered today actually make it possible to tell stories in exhibitions without having these authentic objects stored or on display in museums. In archaeological museum exhibitions, it is obvious that the introduction of more advanced digital tools for display increases the number of possible approaches in communicating archaeological material. One main transformation when digitality enters museum exhibitions is a rapid movement from storing to storytelling. The stories told can, without any doubt, be both fact-based and immersive, as we have seen in the examples discussed in this chapter. But the distance to what traditionally has been conceived of as authentic objects has definitely increased. It is possible to construct stories that have a significant visual impact on the visitor, and at the same time, the presentation does not necessarily rely on the presence of authentic objects – they might as well be digitally produced but still convincingly authentic. Thereby, the storage role of the museum can shift to that of advanced storytelling. By developing methods for managing archaeological information digitally in the field, possibilities for using this information in developing advanced storytelling is enhanced radically. What is now needed is the merging of the different approaches of archaeologists and exhibition makers so that archaeologists' results from field situations can be smoothly taken into consideration and adapted into museum communication using new techniques. And we have only seen the very beginning of this development.

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5 On the potentials and limitations of digital mediation of archaeological information

Per Stenborg

Introduction

This chapter considers how mediation of archaeological information can be facilitated, developed and amplified by applying digital techniques, replication (from physical to digital and from digital back to physical form) and digital means of communication. As the title suggests, the chapter will also point to certain limitations revealed by comparisons with other forms of mediation, for example, direct engagement and direct contact with the authentic 'real things'. It will be argued that whilst archaeological objects can be experienced, as well as interacted with, remotely through digital displays and interfaces, thus reducing the need of spatial juxtaposition between the observer and objects, there are situations where the physical location of objects and the authority over them remains of crucial significance and imposes limitations upon the 'digitisability' of the objects and the qualities they hold (Gibson & Turner, 2011). Regarding questions about the return of archaeological objects to their countries or regions of origin, these limitations become evident. Two examples, one national and one international, are used to highlight some of these issues.

What's on display? Visualisation and perception

Digital ways of presenting and representing cultural heritage may bring the past closer to us, the spectators, while, simultaneously they are situated between the spectator and the past. Consequently, it may be argued that digital visualisations add another layer between us and 'reality' (or, in our case, rather between us and 'the past') – and that it to some extent changes our (as researchers or audiences, etc.) relation to what it visualises. To the viewer of a visualisation of a past item or phenomenon, the reconstruction (or sometimes re-enactment) offers a more or less convincing interpretation as to what was reconstructed and what it may once have looked like. The credibility certainly is related to expectations and perceptions of authenticity (e.g. Holtorf, 2013, p. 433). However, while a material artefact can be identified, or mystified, as 'the real thing' – still consisting of the actual piece of matter that was made into an artefact at some moment in the past (although aged and possibly incomplete) – the digital model of that

artefact – sometimes referred to as a digital object or a digital entity (in the near future a more dedicated designation, such as 'digifact' is likely to gain popularity) – can only claim authenticity in so far as it gives an authentic representation of what it visualises (as long as it pretends to represent a material object). Just as information about both the past and present is spread, copied and multiplied through media, platforms, forums and the like, so are also misconceptions, prejudices and disinformation. As the immaterial digital object (or entity) may usually be multiplied indefinitely, for example, edited, updated and seamlessly extended, the danger of inaccuracies and distortions, thus, occurs here too. The 'digifact' displays several properties more reminiscent of a piece of text (which, it should be noted, still constitutes the largest information type on the Internet) than a material artefact (see the chapters by Börjesson, Dell'Unto and Huvila in this volume). Filmmaker Terry Gilliam expressed similar thoughts in his commentary to Philip. K. Dick's novel, 'The Three Stigmata of Palmer Eldritch', which reads, 'For everyone lost in the endlessly multiplicating realities of the modern world, remember: Philip K. Dick got there first' (Gilliam, 2004). As will be noted in the first of the examples below, digitisation is not a dead end – digitised artefacts may be 're-materialised', for example, through 3D printing.

Information about reality once seemed something that could be stored away from reality itself: in archives, at museums or in magazines. Becoming ever more 'lifelike', but still constituting a branch of that same reality, some have drawn it as far as characterising digital information as 'information as reality' (Borgmann, 1999, p. 2), which would challenge our notions of reality. While others, such as Garstki (2016), agree with the notion that the digital artefact becomes a new thing disconnected from the original artefact, Borgmann takes the arguments further and regards digital information as different from other forms of information – such as film, music or literature – as it may become indistinguishable from the reality it is supposed to describe.

Looking across the disciplinary boundaries, the deceptive potential of realistic reconstructions may be illustrated by the numerous cases in which lizard-skinned dinosaurs have figured in scientific documentaries as well as in popular movies (e.g. the Jurassic Park movie in 1993). In recent years, palaeontologists have discovered evidence suggesting that many dinosaurs were feathered. Even such a 'familiar' species as Tyrannosaurus Rex may, it appears, very well have had feathers (Xu et al., 2012). In such a case, technology has, it seems, helped establish a false preconception of what dinosaurs once looked like. The ever more bird-like dinosaurs emerging as a result of finds of fossilised feathers and other indicators seems at odds with our learned expectations. One may even venture to argue that the established preconception of what the dinosaurs should look like implies that lizard-skinned dinosaurs are perceived of as looking more authentic than feathered ones.

A long-standing criticism of digital methods to reconstruct and present the past (e.g. as 3D models and/or virtual reality scenes) has been the comparably sluggish development of methods of illustrating deficiencies of the data that interpretations are based upon. Uncertainties, ambiguities or gaps (i.e. 'no-data') of the

archaeological record may instead be regarded as an opportunity to invite and inspire audiences or users to contribute and engage in the work of interpreting and reconstructing the past if they can be emphasised, rather than greyed out or filled in by interpolation of surrounding data (Dell'Unto, this volume; Ljungar-Chapelon, 2017).

Reconnecting peoples and pasts – the potentials and the limitations of digital and computer-aided mediation and dissemination

Archaeology may be considered as a discipline concerned with knowledge or information about the past. Therefore, finding, recording, preserving and communicating information are fundamental tasks of archaeological practice. The broad-scale introduction of digital technology in archaeology has been contemporary with an accelerating speed of destruction of archaeological sites and settings. Archaeology of today, hence, is faced with quite different problems in comparison to earlier archaeologies. Hopes of cutting costs, increasing efficiency and productivity have to some extent directed the adaption of digital methods and procedures in archaeology. The following points will be returned to later in the chapter.

First, given the swift development of communication technologies paired with remarkable development, simplification and price drops when it comes to methods for producing realistic models of artefacts (as well as settings, such as site areas), it may be slightly disappointing to find that no abundance of collaborative ventures between different institutions and actors appear to be in the process of publishing joint virtual exhibitions. A reason is, undoubtedly, the fact that development standards and conditions for such joint virtual exhibitions will require considerable time, still, it should be hoped that the emergence of such distributed projects will acquire the financial resources they deserve (for an exception, see Gibson & Turner, 2011). While examples of projects certainly already exist, focus tends to be on the re-assemblage and re-contextualisation of material, rather than on reconnecting people with historic and prehistoric material.

Second, it has been argued that the dispersed state of much cultural heritage held by museums and institutions primarily in the Western world can be productive as promoters of international collaboration (e.g. Basu, 2011, p. 37). The process of repatriation or restitution of cultural heritage may create conditions for collaboration, interchange and communication far beyond the confines of the cultural heritage sector (Hennessy, 2009).

Third, the significance or meaning of an object may differ, depending on, for instance, social and cultural background of the interpreter or describer (Boast & Biehl, 2011, p. 145). Hence, although the information presented through models, images or movies may appear relatively unambiguous in the eye of particular presenters, it may become a starting point for diverse, even contradictory, descriptions.

Fourth, different equipment for displaying the model will produce different visualisations – actually, apart from the 3D-model itself, the entire technology-chain

involved in the image production will influence the image displayed (and in a similar manner, the chain leading to the finished 3D printed object will affect the properties of that object).

Finally, the transfer of physical remains and other kinds of archaeological material from their places of provenance to other parts of the world has a long history of its own. Tracking such movements in the past and present would shed light on many aspects of contacts, collaboration, conflicts, trade and networks that directed these movements. This also implies that not only have these processes resulted in increasing dispersion of archaeological remains, but actually, to a concentration of material of various origins in certain locations of the world. From a local perspective, it has nevertheless led to a diaspora of historical material originating from specific geographical localities. Although this broad topic cannot be specifically addressed in the context of this chapter, colonialism and its many consequences led, among other things, to socio-cultural inequalities, marginalisation and subalternism, as evidenced by late twentieth-century debate (e.g. Fabian, 1983; Fanon, 1965; Thomas, 1994; Todorov, 1982; Wolf, 1982).

Based on the aforementioned notion of cultural remains as a form of information content, the interconnected characteristics of the contemporary world should offer excellent opportunities for reassembling scattered parts and pieces of history. An initial analysis of the potential and the limitations of digital and computer-aided mediation and dissemination, in the case of archaeology, gives knowledge about, and visualisations of, archaeological material (i.e. artefacts) as suitable objects for digital dissemination of information and have considerable potential to put people in touch with their historical and cultural background. On the other hand, this is much less the case concerning notions or experiences of qualities such as authenticity or rehabilitation for historical wrongdoings.

The physical returning of cultural heritage objects is therefore an issue that brings about a much broader set of questions than merely those directly tied to the matter of repatriation of wrongfully acquired objects. Relocation of objects may also serve as a political gesture of recognition of wrongdoings that accompanied and surrounded the creation of collections. The gesture aspect or functionality associated with physical repatriation is most evident when it comes to well-known and highly valued items.

In all likelihood, the majority of objects held by ethnographic museums and their heirs in Europe and North America will neither be reclaimed nor returned. Large collections of primarily fragmented material (e.g. pottery shards) are less likely to be returned than collections consisting of a limited number of prestigious objects. As previously mentioned, some researchers have pointed to the potentials of this kind of collections as a basis for building up fruitful connections and collaborations (see, for example, Basu, 2011; Gibson & Turner, 2011; Hennessy, 2009).

The value of the past, its significance or importance is certainly a subjective matter. A project aimed at reconnecting people with their past cannot assume any particular attitude towards the past to be held by the target groups. The past may be of greater or lesser importance for living people and notions about the relation

between history and ancient material culture (artefacts, buildings, etc.) varies. Assessment of history and the past also relates to a number of conditions and varies over time. This may particularly apply to people living in regions that have suffered colonisation or conquest (Stenborg, 2012a).

Examples

Two quite dissimilar examples will be presented below. The first concerns a research and development project, with the particular aims of developing, employing and evaluating new and innovative forms of digital mediation and communication of cultural heritage information. The second example concerns a strict research project, which emerged out of cooperation with Brazilian colleagues – primarily with Dr Denise Pahl Schaan in Pará – concerning rescue archaeology related to road construction projects (Br-163). From 2011, the Cultivated Wilderness-project carried out archaeological fieldwork (excavations and mapping), as well as environmental research at selected archaeological sites in the Santarém region, Lower Amazon. The project also had bilateral compositions allowing Brazilian researchers and students to work with Santarém-material (acquired back in the 1920s) in the collections of the Museum World Culture in Gothenburg. Given that the project had no particular resources for public mediation, such efforts were largely made on a voluntary basis. The two examples therefore result in a discussion of how possible future communication projects in an international context, such as that of Example 2, could be designed.

The Vittene torque

In 2007, a project titled Digital Time-travels was launched in Gothenburg, under the direction of the author, and with researchers and staff from several universities, representing a number of different disciplines, including archaeology, architecture and environmental research. The research and development focused work in the project involved the development of several new methods of presentation and publication of archaeological data using digital and computer-aided methods. One part of the project involved 3D scanning, and subsequent digital and material modelling of gold artefacts belonging to the Vittene treasure, originating from west Sweden, for use in a museum exhibition at Lödöse Museum. The physical artefacts are currently housed at the Swedish History Museum in Stockholm. As the work and results of the project have been extensively dealt with in other contexts (e.g. Stenborg et al., 2010, 2013), the reasons for returning to this subject in the context of this chapter relates to a certain spin-off from the original project. One of the arguments for allowing the high-resolution 3D scanning of the gold material was that it would not only be of use within the project and the particular museum exhibition in question, but that it would also satisfy future needs of making copies of the artefacts, thereby protecting the material from the risks associated with handling and transportation. Five gold artefacts were scanned in 2008 (Figure 5.1), using an Athos II scanner.
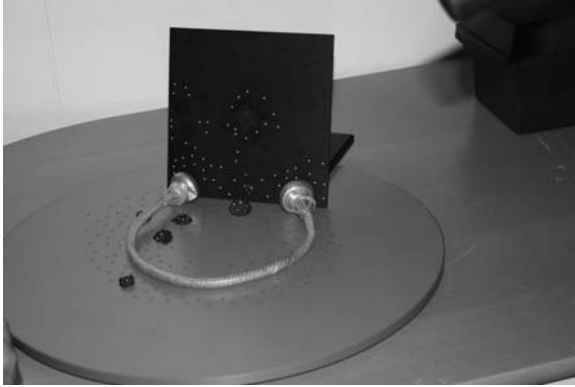
Figure 5.1 The original torque during scanning at the Swedish Historical Museum in Stockholm 2008. Photo by the author.

One of the artefacts, a *torque* (a kind of neck ring), was also physically reproduced from the digital data and exhibited as part of the exhibition *Älvresan* (The River Journey) at Lödöse Museum (Figure 5.2), while digital models of other objects were displayed using a touch-screen based interface. Almost six years later, in early 2014, a local history association, Åsaka-Björkes hembygdsförening, contacted the author expressing their interest in getting access to the digital models that had resulted from the scanning of the *torque* and other objects back in 2008 (Karl-Gustav Danielsson, personal communication, 2014).

This request gave the project an opportunity to implement the original intention of improving the accessibility of the material represented by the models from the scanning, while at the same time, also saving and protecting the physical artefact to the extent that the digital model could take its place. The digital models had been stored in several formats, including the .stl (STereoLithography) format widely used in rapid prototyping and 3D printing. This reduced the probability of quickly arising obsolescence of file formats and resulting lack of compatibility with new software by storing models in a well-established standard format.

The primary aim of the local historical association was to draw attention to the Vittene finds. The museum run by the association is located 400 km from Stockholm, where the original artefacts are currently housed, but close to the site where the treasure was found in the 1990s. The website of the Digital Time-travels project was still online at that time and it was through the site that the association had found information about the scanning of the gold artefacts. The idea of creating additional physical copies of the artefacts using the existing digital models thus came up. The physical copy used in the exhibition in Lödöse had been created in assembled bronze and plastic material at the School of Architecture and Design, in Oslo, Norway. The association was able to 3D print physical copies using filament-printing. Although the level of detail is lower in

Figure 5.2 A physical copy of the torque produced from the digital data acquired by scanning in 2008. This picture shows the copy on display at Lödöse Museum in 2009. Photo by the author.

comparison to the previously used method, the result was more than sufficient for their purposes (Figure 5.3). The museum of the Åsaka–Björke local history association is visited by school classes, as well as the local community. The copies of the gold objects are presented in an exhibition with information about their historical context and the circumstances surrounding the finding of the Vittene treasure in the 1990s.

According to Karl–Gustav Danielsson (personal communication, 2016) of the Åsaka–Björkes hembygdsförening, affordability was a more important factor than issues such as the number of steps of processing and modelling that separated the copies from the original artefacts. The models thus managed to bridge the gap imposed by the spatial distance to the material, implying that, in some sense, the objects became more real and present in the museum and could be used to enliven and re-contextualise the treasure and the history associated with it.

Archaeological material from the Brazilian Amazon in Gothenburg

Large collections of archaeological material from the Brazilian Amazon are housed at the Museum of World Culture in Gothenburg, Sweden (Figure 5.4). These collections have their background in the work of Curt Unkel Nimuendajú in the 1920s and the collaboration between this German-Brazilian researcher and the Ethnographic Museum in Gothenburg, at that time directed by Erland Nordenskiöld (see, for example, Muñoz, 2011; Neves, 2004; Nimuendajú, 2004; Stenborg, 2004).

Figure 5.3 Copies of the objects of the Vittene treasure on display at Åsaka-Björkes hembygdsförening in 2016. These copies were produced from the datasets collected in 2008. Photo by Karl-Gustav Danielsson.
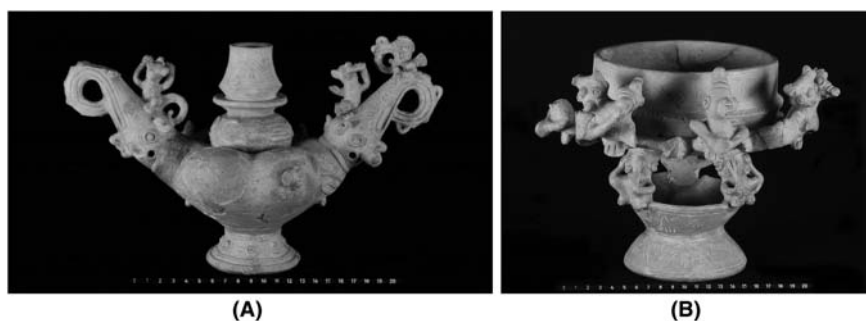
Figure 5.4 Two examples of Santarém phase pottery belonging to the Brazilian collection at the Museum of World Culture. From Nimuendajú 2004.

In 2011, a broad bilateral research project involving researchers from archaeology and environmental science in Sweden and Brazil was launched under the name Cultivated Wilderness: Socio-economic Development and Environmental Change in Pre-Columbian Amazonia (Schaan et al., 2015; Stenborg, 2016; Stenborg et al., 2014, 2018). Besides the organisation and implementation of joint fieldwork in Brazil, the project also included Brazilian researchers and students visiting Gothenburg to work with the material in the museum's collections. From a scientific point of view, this was a way to reconnect the material in the collections to present-day research on pre-Columbian Amazonia, as well as to make the material more accessible for researchers and students from the country of its provenance.

Being a research project, the principal Brazilian partners were researchers and students, for whom access to the archaeological material in Sweden was improved

through the establishment of the project. Some work of the project was also directed towards the general public. The project website published information on the fieldwork as well as analyses of archaeological material at the Museum of World Culture in Gothenburg. Some 3D models of artefacts were made available online (Figures 5.5 and 5.6). The project also participated in community work on location in Santarém.

A simple, albeit blunt, way to analyse the use of web-content is through web-statistics. Web-statistics is a somewhat deceptive source of information. Many visitors are anonymous, or may appear to visit a website from another place than that of their real physical location.

The Cultivate Wilderness website was launched in the first year of the project – 2011. The web-hosting provider changed its method of documentation of web statistics in 2012, making comparisons with the statistics gathered before 2012 difficult. In this comparison, therefore, only statistics from 2012 on are used.

In general, Latin America has accounted for a comparably small share of the web-traffic on the site. It should be noted that for approximately 50% of the visits to the site, the country of origin could not be determined. It remained unknown or unresolved.

By restricting comparisons to Brazil and Sweden, a trend can most easily be seen by comparing the statistics for a given month. November has been selected as

Figure 5.5 A figurine (ocarina) photographed in 2010 for subsequent 3D-modelling. Photo by Per Stenborg.

Figure 5.6 A 3D-model of the figurine on display at the project homepage.

the month of comparison as it shows somewhat less volatility compared with other months. Corresponding statistics from that month exist for the project period of 2012 to 2014, as well as for 2015 and 2016 (as the website has remained online after the end of the project) (Figure 5.7).

In November of 2012, 59 hits to the domain were registered as coming from Brazil, giving it ninth place on the list over countries from which visitors came. As might be expected, the highest number of hits came from Sweden, which accounted for 3493 hits [59/3493].

In November of 2013, the number of hits from Brazil had risen to 203, making it the seventh most common country on the list. At the same time, the number for Sweden had fallen to 474, which placed Sweden in third place after both Ukraine (1178) and Poland (626) [203/474].

In November of 2014 (the last year of the project), 444 hits came from Brazil, placing it as the second country on the list, only behind Sweden with 684 [444/684].

While the web domain has remained online post-project, updates of information and content have been more sporadic.

In November of 2015, the number of hits from Brazil had fallen to 71, which made it the ninth country on the list. At the same time, the number of hits from Sweden went down to 169, placing it sixth on the same list. At the top of the list were 44,599 hits from the US [71/169].
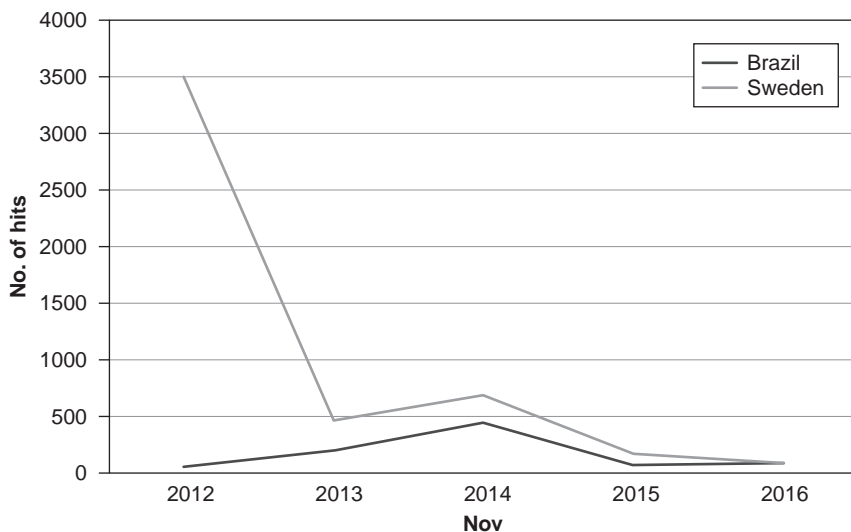
Figure 5.7 Comparison of the number of hits from Brazil and Sweden on the 'Cultivated–Wilderness' website in the month of November over five consecutive years (2012–2016).

In November of 2016, the number of hits from Brazil was 87 and the number from Sweden was 93 (seventh and sixth on the list), most hits came from Russia (627) [87/93].

The numbers show considerable volatility and must therefore be treated with caution. Apart from the dramatic fluctuations found in portions of the statistics – which is likely to be related to, for instance, world events, changes in classification of web-domains, possibly also hacking attempts – a comparison of the numbers of hits from Brazil and Sweden, nevertheless, points to a continuous trend over time. The same trend can also be seen in the statistics for other months (Figure 5.8), where in some cases, Brazil surpasses Sweden in the number of hits in the latter part of the period from which data was collected.

Active updating and connection to an ongoing project are, hardly surprising and applying to most of the online world, necessary to maintain the attractiveness of a website. Public dissemination and communication was, in the case of the Cultivate Wilderness project, at a quite elementary level and the information on the website was only available in English. Apart from presentations in connection with fieldwork (Figure 5.9) and efforts by the Brazilian part of the crew in relation to this and other projects carried out in the same region, the possibilities of directing information towards particular target groups were limited.

In spite of some glaring differences between the two cases, there are also similarities that should be noticed. Comparing the situation of the archaeological material held by the museums (i.e. the Swedish History Museum in the case of the
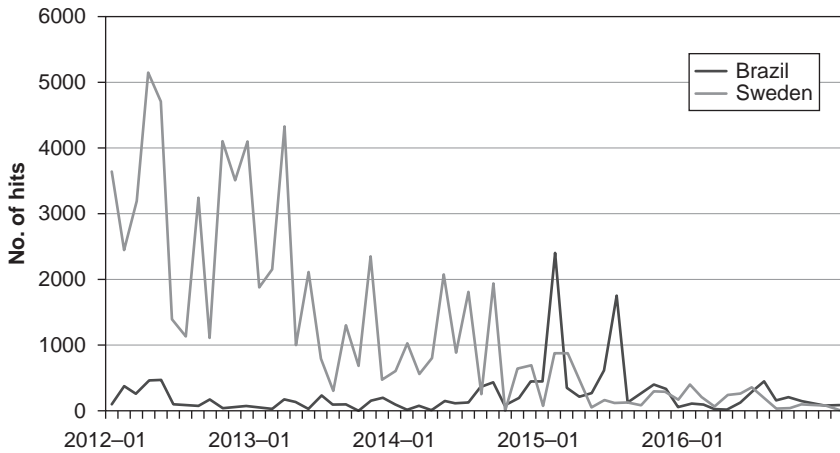
Figure 5.8 Monthly statistics of the number of hits from Brazil and Sweden on the 'Cultivated-Wilderness' website for the period January 2012 to December 2016.

Figure 5.9 A local family outside Santarém examining pottery fragments together with project members. Photo by Per Stenborg.

Vittene artefacts and the Museum of World Culture in the case of the Santarém-material), some analogue circumstances, albeit on very different scales, may be pointed out. In both cases, the material is kept at a museum outside their region of provenience. Thus, the exhibitions held in these museums would not primarily address local communities in the area of origin of the material.

In both cases, therefore, there was a spatial-geographical discordance between the present location and the origins of the materials. A primary objective of the digital communication and mediation in both cases was to (re-)connect people with cultural heritage.

Prehistory and prehistorical societies are remote or foreign in relation to the present due to the temporal distance alone. The relocation of archaeological finds from their areas of origin therefore adds distance on yet another dimension. In such cases, projects aimed at reconnecting people with their past thus have to bridge space as well as time.

Conclusions

As seen in these and many other examples, the use of computer-aided and web-based methods for mediating archaeological information has great potential in improving the access to such information for large parts of the world's population. One reason is that online distribution of information about archaeological materials may connect people with objects and other materials that physically are remotely located. Although the loci of such meetings, from the point of view of someone gaining access to something through the web, will appear to be situated somewhere in the interface used to gain access (and thus in-between the observer and the observed), the meeting may, at the same time, create an illusion of traveling through both time and space and to be close to that which is on display.

Allowing people to learn about – as well as to connect with – historical artefacts provides them with resources and material for various purposes, such as identity building, artistic expression or handicraft. Many such aspects of artefacts and material culture can be experienced in a meaningful way through digital interfaces and media. Obvious limitations are the difficulties of transferring experiences beyond those related to sight, hearing and even touching by digital or digitally mediated means. Qualities such as authenticity and uniqueness are only partially transferable using digital techniques. The first example, however, shows that a digital model can be helpful in re-materialising an object, which, in turn, can be touched, as it possesses a surface structure and weight – even if all of its properties do not necessarily match those of the original artefact.

On another level, there are situations where the location (or housing) of the original, authentic, physical material is the central issue. Ability to study (or interact with) objects (or rather representations of them), no matter how closely, will not be sufficient if possession and ownership is what matters. There are historical circumstances that may transform an object into a symbol of past wrongdoings, injustices or exploitations. This is doubtlessly the case when objects have been obtained illegally, through acts of war, plundering or colonialism.

Concerning the two contrasting cases dealt with in this chapter, the level of details as regards the users or recipients of digital mediation differs.

In the west Sweden case, quite specific information about users, as well as use, is at hand. Notably, the case was an offspring of an original project that focused on mediation, a project that itself had included interviews with users of the digital

applications developed within the project, as well as a questionnaire-based investigation of the experiences of museum visitors attending the digital exhibitions designed by the project (Stenborg, 2012b; Stenborg et al., 2010, 2013). The research and development project was carried out in close collaboration with cultural heritage institutions. A merit of the offshoot described in this chapter is the fact that this initiative came from outside the project itself. The possibility of such offshoots had been anticipated in the context of the 3D scanning of artefacts and was encouraged by the project.

The second, international case was essentially limited to analysis of web-statistics from a website presenting a research project, and as such, susceptible to misrepresentations of such data. No detailed information about users was collected beyond the country registered as the location from where people visited the website. Comparing the number of visitors from the country housing the collections (Sweden) and that of the origin of the material (Brazil) revealed a notable trend over time towards an increase in the number of visitors from the country of origin. While these figures probably partly reflect, for example, an increased frequency of visits from research-partners in Brazil and a trend towards improved Internet access in that country, they also suggest that the Internet offers an opportunity to reach out to audiences that otherwise would not gain access to such information about their heritage and history. It is to be hoped that broad international initiatives will improve the possibilities for people to discover their history and cultural heritage, not letting geographical distances become obstacles.

This also leads us to recognise certain important limitations of mediation of the kind of information dealt with here. Future projects will need to develop better means of two-way functionality beyond interactivity. This, in turn, will require new forms of administration of web-content and social media, and the overcoming of obstacles for communication (e.g. one multilingual, rather than several alternative versions of the same information in different languages). Concerning the civil use of the Internet, we are now well past a formative period marked by an enthusiastic, albeit sometimes naive, pioneering spirit. Coming of age, the promise of a more democratic and distributed Internet still glimmers, but at the same time, the threat of a controlled or contorted Internet seems real. Open access to information is therefore something that needs to be constantly protected and promoted. We are also constantly reminded that 'Open' information is not synonymous with 'True' information. Propaganda, manipulation and falsification of history can also take advantage of the growth in the flow of information – although the number of fact reviewers is likely to rise as more and more people get access to information – we still have reason to remember that openness may be turned into emptiness, or perhaps decadence, if it is not accompanied by visions and goals that are constantly being openly developed and debated. Efforts to improve the access to information about history cannot ignore issues about who can access the information. Improvement of accessibility should therefore be combined with a dialogue about the importance of history, as well as studies on the use of history.

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6 Ecology of archaeological information work

Isto Huvila

Introduction

After excursions to changing information work and knowledge-making in archaeology, this chapter sets to propose a more systematic understanding of contemporary archaeological information work. Such an understanding is useful both for unravelling why archaeological information work is as difficult as it seems to be according to the snapshots of specific archaeological practices offered by the earlier chapters in the volume and the common knowledge of archaeologists alike. Simultaneously, it is helpful in developing information management practices both in archaeology and beyond. Informed by soft systems thinking, Gibson's ecological approach, infrastructure studies and information management literature focuses on, rather than in archaeology, even if, as the reckoned theoretical premises imply, the subject of inquiry unavoidably lingers between archaeology and the study of archaeology. Taking the latter perspective, a closer scrutiny of archaeological practices also ties it to the broader landscape of information work in everyday life settings beyond specific contexts and situations of archaeological work.

Archaeology as a soft system

Looking back at the earlier chapters of this book, archaeology and archaeological information work can be described without much controversy, using the term coined by Nelson (Dechow & Struppa, 2015), as deeply 'intertwingled' enterprises. At the same time, archaeology is not a haphazard enterprise. There is a great deal of systematicity both in the ideals that guide archaeological practices and information work from theory and methods to policies and guidelines, and in how archaeology is conducted in practice. As such, it is apparent that the systematic understanding of the archaeological enterprise requires an inherently complex frame of reference, even if the aim would be to say something simple about them. It is this paradox of the coexistence of apparent intertwingularity and systematicity that has guided the direction of inquiry in this chapter and its orientation towards soft systems thinking. This perspective gives basic keys to unlocking some of the intricacies of how archaeological knowledge comes to be

in contemporary society. On a very basic level, the examples discussed in this volume from widely different areas of archaeology evince of the systemic rather than purely random intertwingularity of how archaeological information comes to be, what the information is and what outcomes and implications it has. Stenborg's discussion of what is real, what is reconstructed and what implications the perceived reality of artefacts and unreality of digital objects have highlights the intricate relation of material forms of information and how it is experienced.

As originally drafted by Checkland (1981), the soft systems approach was proposed as a method for explicating and understanding constellations of activities, technologies and people that are difficult to quantify in formal terms in technical systems. In the context of archaeology, these constellations range from fieldwork and scholarship to governance of archaeological activities in society and beyond to public archaeology and education. The soft systems approach builds on the perspective of systems thinking to conceptualise activities and their constituents in systemic terms, however, at the same time, explicitly refusing the reductionism of natural sciences and the expectation of the general systems theory to function as a general theory of everything in social sciences (Langlois, 1983, p. 581). In comparison to the general systems thinking, the novelty of a soft systems approach is to acknowledge the significance of the human factor (Checkland & Holwell, 1998, pp. 46–47). The second major difference is that while hard systems approaches tend to conceptualise the world as systemic, the soft approach sees the process of inquiry as systemic (Checkland, 2000). In this sense, it represents a similar shift than the move from first-order to second-order cybernetics, from observing external systems to foregrounding and problematising the role of participant and observer in the study of systems (Mingers, 2014). While acknowledging the complexity of systems involving both technical and non-technical components, a soft systems approach adheres to the functional rationale of engineering in how its attempts to provide a structured understanding of the functioning of those systems and especially in the context of the soft systems methodology (SSM), to function as an instrument of change in the spirit of action research (Checkland, 2000). Even if it is common (e.g. Schatzki, 2001) to contrast systems theory with practice and activity centric approaches (including ANT and especially practice theory), in its strive to use a systemic inquiry to organise complexity, the soft systems perspective can be seen as complementary rather than as their antithesis. An example of an approach that puts equal emphasis on human and non-human actors is Pickering's socio-material approach, which conceptualises the intermingling of material things and human-beings as a mangle of practice. Pickering acknowledges that objects make things to happen but puts in a specific effort to explicating the differences between the agencies of material and social actors (Pickering, 1995).

The central tenet of this chapter is that, similar to other types of constellations of interrelated activities, archaeological practices can be conceptualised as forming a soft system, or multiple overlapping and parallel inter-linked soft systems within, on the boundaries and outside of 'archaeology'. The benefit of this approach is that it provides us solutions to explicate existing interrelations and

on-going reconfigurations of people, technologies and practices in how archaeological information works and in knowledge-making changes. The emphasis of soft systems thinking to problematise the role of observer/participant (Checkland, 2000; Mingers, 2014) has been central to the inquiry that led to the writing of this volume in a group consisting of archaeologists and non-archaeologists, but also from a conceptual perspective, as a starting point of interrogating how different actors can be observers and/or participants in an archaeological enterprise. On a conceptual level, I am inclined to propose that a system can be understood, borrowing from Hiebert (1983), as a 'centred set' within which everything has a certain distance to archaeology, rather than seeing it as a categorically bounded set of things, either being archaeological or not. These 'archaeological' systems stretch from the practices of fieldwork and archaeological scholarship to the systems of governance of archaeological activities in society, of development of technologies, methods and approaches used in archaeology, archaeological pedagogy and aesthetics. They incorporate archaeological and archaeology-related activities from artefact analysis and surveying, technologies of documenting and managing archaeological information to human actors, including archaeologists, administrators, land developers, curators and museum visitors. As such, the system of systems of which archaeology is a part, is far larger than the discipline of archaeology, and as Olsen (2012) remarks, the ecology of archaeological practices does indeed go well beyond what archaeologists do or did. Even if it might be tempting to see archaeology as a closed domain with little inference with society at large, the archaeology-as-a-system is an indivisible part of the society-as-system. From this perspective, as long as there is a society, there is no archaeology beyond society and as long as archaeology is carried out in society, then society is not archaeology.

There are obviously many different alternatives to theorise work and information activities in general and within a particular domain. Proponents of relational theorising have criticised the systems theory of substantialism (Schultze, 2017), a criticism that also applies to soft systems thinking. The real substantialism of the approach depends, however, somewhat on how much focus is put on the system-as-an-artefact and how much on the processes of their becoming, practicing and change. Some of the advantages with soft systems thinking is that it accounts for both human and non-human actors and acting, it acknowledges the heterogeneity of their interlinkage and the heterogeneity and number of different factors that influence and transpire in these relationships and their becoming. It is also reasonably holistic, and while being helpful in analysing and understanding information work, it is a prescriptive and action-oriented process that explicitly aims at empowering human-actors to improve a situation.

The diverse aspects of archaeological work discussed earlier in this volume illustrates the breadth of archaeological activities, as well as the actors with a stake in archaeological work. Even if, as Löwenborg reminds us, most the archaeological work never makes it to the headlines in mainstream media, archaeology makes a difference in a broad variety of contexts. Development-led archaeology is a legal requirement in Sweden, and in large parts of developed countries, it is an

elementary part of the process when railways, roads and houses are built and renovated. Archaeological sites and museums are popular sights as Petersson notes. Archaeological considerations play a significant role in contemporary cultural and cultural heritage policies as both Börjesson and Huvila's, and Stenborg's chapters evince.

Instead of digging deeper in the specifics of different archaeological practices using the formal tools provided by Checkland's SSM, we refer to the notion of soft systems in more general terms as a framework that helps us to understand the interconnections, gaps, synchronicities and asynchronicities of archaeological and archaeology-related practices from fieldwork and documentation to communication, archiving, administration and repatriation. Each of these activities makes a soft system of its own, some of the activities come together in larger systems and the entire archaeological enterprise as a whole, forms a vast soft system of systems. All of the systems comprise of both human and non-human actors that form a mangle-like (Pickering, 1995) systemic apparatus of archaeological activities. The different chapters of this volume have described and discussed a large number of these actors, both humans and non-humans, but also actors and constellations of actors that increasingly overlap. Policy-makers and policies are both actors with an influence on how archaeology is exercised in society and how the conditions for its longevity are articulated and practiced now and in the future. Museum visitors, curators and exhibition designers all participate in communicating archaeology together with a broadening range of digital and non-digital technologies that mediate the visitor experience. Local communities, both close and far, are actors with a stake in how archaeology is perceived and exercised in society, and how and when archaeological artefacts participate in the making of both archaeology, and identities and practices beyond what is traditionally understood as archaeology. For archaeologists, their trade is increasingly intertwined with the co-acting of new technologies and methods and technology, and methods experts from statistics and mathematics to computer and natural sciences.

Another reason of referring to soft systems thinking is that it gives a possibility of looking closer into how digital technologies reconfigure archaeological practices and how these reconfigurations in different parts of the archaeological enterprise influence each other. Löwenborg points to new opportunities large data sets provide for archaeological research. The novelty is not only in that a new tool has been introduced to perform an old task of conducting large scale analyses but that the technology makes it possible to ask new questions. The same applies to photogrammetry based field documentation in Dell'Unto's article. Field archaeologists do still excavate, but the process of digging and interpreting the findings is changing. In comparison with the traditional pen and paper documentation, photo-documentation intertwines documentation and excavation more intimately than it was possible before.

It is not enough to describe how a technology enters a mangle of practice (Pickering, 1995). It is necessary to take the challenge of Stengers (1997) and take a risk to try and show how certain technologies have very specific implications on

the particular parts of the archaeological soft system and the outcomes these systems produce. These technologies do not enter the soft system out of nowhere. They are introduced by humans and humans use them to achieve particular goals. The technology itself can be anything from hard technologies such as digital photography and laser scanning to soft social technologies and their hybrids from digital archives, digital government and digital humanities (specifically conceptualised as technologies). The 'digital' incorporates a reference to a technical form of digitality as a binary representation, but stemming from digital being understood rather as a social term than a technical term; digital is a property of things understood as being related to 'digital' rather than a definite token of its belonging to the technological digital realm. Especially in museum contexts, the intrinsic value of inserting digital 'elements' in exhibitions is a convincing example of the essential rather than instrumental significance of digital technologies. However, even if similar tendencies were more vested in other contexts, they are not necessarily absent. Digital technologies have a capability of changing archaeology and archaeological work in field as Dell'Unto demonstrates in his chapter, they can be helpful in providing new perspectives to earlier collected data and to bring together insights from small, individually meaningless, field projects. Further, as Stenborg's examples show, even if digital technologies might not function as a substitute for physical restitution of artefacts, or as Boast and Enote (2013) critically remark that virtual repatriation is virtual but has little to do with repatriation, it can still provide means to make archaeological collections more accessible for different audiences in both physical (as in Lödöse) and non-physical (Brazilian collections in Gothenburg) forms.

Archaeological work and information work

Instead of attempting to say something definite about the digitisation of archaeological work as a whole, the main interest in the exploration of archaeological work in this book has been in archaeological information and its role in how archaeology is performed. While doing this, it is impossible to avoid saying something more general and by discussing the digital in the context of archaeological work, much of that discussion is unavoidably about information. Star and Strauss (1999) made a widely cited distinction between visible and invisible work that is helpful in understanding the relation of work and information work. A simple definition of work is to see it as an activity with purpose, meaning and value (e.g. Huvila, 2009). In systemic terms, work can be considered to form a theoretical system consisting of multiple secondary, mutually overlapping systems. The premises, objectives and perceived implications of work differ between individuals. Often, the understanding of what counts as 'work' is normally shared in a community but the understanding of any particular instance of work as 'work' does not need to be completely the same (Star & Strauss, 1999).

In spite of the apparent overlap of work and information work, it makes sense to make an analytical distinction between the two. In the literature, the notion of information work has been used to refer to the informational sub-work that is a

part of all types of work (Huvila, 2009). All work, including diverse configurations of archaeological work, incorporates elements of seeking, organising and using information whether it is codified, formal or informal, found as a result of an intentional effort or discovered serendipitously. As a work-related second-order activity, it is comparable to the computing work of Gasser (1986). Even if information work can be explicit and in some cases even the principal activity of a professional information specialist or archivist, in the context of archaeology (e.g. Huvila, 2016), in most cases, it is infrastructural and 'invisible work' (Star & Strauss, 1999) that silently supports and makes the primary work possible. Curatorial work at museums and especially the work of keeping and sorting out the correct kind of data for archiving discussed by Börjesson and Huvila beyond the, in practice, rather symbolic guardianship comes close to typical examples of invisible information work discussed in the literature. They are necessary and infrastructural by their nature but remain largely unrecognised as a crucial part of the archaeological enterprise. Even those who are involved in primary information work are performing secondary, invisible information work to support their main work. The chapters of Löwenborg and Dell'Unto show how this invisible work is omnipresent in archaeological research and fieldwork. In many cases, its invisibility stems from its conspicuity as an integral part of the archaeological enterprise. However, as both Dell'Unto's work for the development of field documentation methods and Löwenborg's work on legacy data show, its invisibility becomes evident first when work practices change and its stakeholder begin to question the compatibility of established procedures of work in the new situation.

The exploration of the convergence, friction and change of archaeological information work so far in this volume shows its irrefutable diversity. Archaeological knowledge is not made only at the (literal) trowel's edge (cf. Berggren & Hodder, 2003) in the field or at universities. Digital technologies from 3D documentation to GIS have become, or are becoming, a new trowel, a tool for archaeologists to (almost literally) unearth new knowledge. Petersson's studies on how archaeological information is used and unused at museums reveals another perspective to how archaeological knowledge is made in another milieu from highly different premises and framed within another field of a practice. In a strict sense, it is not implausible to doubt that archaeology would form one single domain. To a certain extent, everything that is called archaeology or related to 'archaeology', in Hiebertian (Hiebert, 1983) terms belonging to the particular centred set, can be dubbed as archaeological information work, but it does not mean that all of these activities would be equally influential or central in the general process of making archaeological knowledge – understood as the knowledge that is generally and in specific cases appreciated as central knowledge within the domain of archaeology. They are certainly influential for their own right within their own contexts, but they do not necessarily play a central role in archaeological thinking (Orser, 2014) in how archaeologists use logic and analogy, and compare, contextualise and evaluate materials. Therefore, it is significant to note, from the soft systems perspective, the diverse worldviews that

lead to different forms of archaeological knowledge and their associated forms of information work by their own right without losing sight of how they are entangled together in producing a mesh of knowledge. Even if they are connected, archaeological fieldwork, landscape analysis and public archaeology all differ in their premises and are simultaneously distinct branches of work with their respective informational second-order activities, namely, information work. At the same time, however, they can still be centrifugal, and belong, to the centred set (Hiebert, 1983) of archaeology, some of them being more distant from its nexus than others. In many respects, the information work of professional and amateur archaeologists can be close to each other (Stebbins, 1992), and their distance to the kernel of archaeology can be very similar. On the other hand, as Stenborg shows in his discussion of artefacts in public contexts, the particular actions and circumstances when and where public archaeology takes place, can put them on highly different trajectories and positions in the centred set (Hiebert, 1983) with their distinct local discourses (Deeley et al., 2014).

On the basis of the observations on the diversity of the archaeological enterprise, it is easy to agree with Morville's (2014) claim that human nature, especially our impatience, and mechanistic tendencies in organisational cultures are, or at least can be, problems in the context of archaeological information work. More patience with archaeological and archaeology-related work could be helpful in trying to understand, communicate and take into consideration the diversity and change of archaeological information and its implications and meaning for different stakeholders. Simultaneously, balancing between the need to standardise and improve the interoperability of archaeological information (underlined for instance by Löwenborg, and Börjesson and Huvila) and the inescapable diversity of perspectives, vividly exemplified by Stenborg, requires an organisational attitude that takes seriously the complexity of the archaeological enterprise and resists temptation to formalise it in excessively mechanistic terms.

Infrastructures of archaeological information work

A closely related notion to information work is information infrastructure. They are both constituents of the soft system of archaeological work but also systems in their own right with particular roles in the larger constellation of how archaeology is achieved. There has been a raising interest in the concept and related notion of knowledge infrastructure in various branches of information sciences, science and technology studies and anthropology (Karasti et al., 2016), and in the relatively new, proposed cross-disciplinary field of infrastructure studies (Edwards et al., 2009; Ribes et al., 2012) and its branch of information infrastructure studies (Bowker et al., 2010). Information infrastructures, like all infrastructures, allow, facilitate and shape our surroundings and their conditions, and form an invisible substrate for activities. Rather than being an essential thing, an infrastructure is in a constant state of becoming (as for Whitehead, 1978) and as Star and Ruhleder (1996) remark following Engeström (1990), it is more appropriate to ask when is an infrastructure rather than what it is. They continue

to note that infrastructures tend to be invisible and become discernible only when they fail. We are 'plugged in' (Star & Ruhleder, 1996) in to them as a part of our daily activities, and according to their now famous breakdown, they are characterised by embeddedness, transparency, their reach or scope beyond a single event of practice, they are learned as a part of membership, they link with conventions of practice, they are embodiments of standards, built upon an installed base, and as noted, they become visible upon breakdown (Star & Ruhleder, 1996). Star and Ruhleder (1996) note further that information infrastructures are not to be considered as substrates that carry information, but rather in a Latourian (Latour, 1993) sense, dichotomies of mind and body that traverse the great divide of human and non-human, or perhaps in a Whiteheadian (as for Whitehead, 1978) sense, refute the existence of these divides altogether. Star (1999) posits that an information infrastructure can be read either as a material artefact constructed by people, a trace or record of activities or a veridical representation of the world. Mongili and Pellegrino (2014) note specifically on information infrastructures that go beyond information artefacts in that they are relational to organised practices. Some information artefacts become infrastructures (Star & Lampland, 2009), like how some artefacts become information (Buckland, 1991) depending on the situation. In an attempt to present a working definition of information infrastructures, Monteiro et al. (2012) stated the following:

> Information infrastructures are characterized by openness to number and types of users (no fixed notion of 'user'), interconnections of numerous modules/systems (i.e. multiplicity of purposes, agendas, strategies), dynamically evolving portfolios of (an ecosystem of) systems and shaped by an installed base of existing systems and practices (thus restricting the scope of design, as traditionally conceived). Information infrastructures are also typically stretched across space and time: they are shaped and used across many different locales and endure over long periods (decades rather than years).
>
> (Monteiro et al., 2012, p. 576)

As Borgman and colleagues (2016) stress, they do not persist if care is not taken. The fragility of infrastructures has been very obvious throughout this volume. Löwenborg shows that their fragility already becomes evident before an infrastructure comes into being. Stenborg and Petersson both touch upon the issue of how use and reuse make, and unmake, infrastructures in museums and museum collections. Dell'Unto, and Börjesson and Huvila, do for their part suggest of the fragility of information infrastructures when the forms and formats of documentation are changing.

Unsurprisingly, a multitude of infrastructures can be traced in the backyard of archaeological information work. Olsen (2012) points to the significance of the emerging heritage legislation as a central infrastructure of archaeological practices in the nineteenth and especially in the twentieth century. He also refers to

standards and knowledge infrastructures as infrastructures for archaeological knowing, thinking and remembering. The institutionalisation of archaeological work, its administration and management at universities and societies, national and regional, public and private organisations, collections, laboratories and scholarly journals has simultaneously been a process of establishing infrastructures to support, not only archaeology at large, but also more specifically, archaeological information work. Huggett (2016) draws further attention to the invisibility of infrastructures and unawareness of the consequences of investing and building 'cyber-infrastructures' for archaeological work. He draws on infrastructure literature (e.g. Day, 2014; Kitchin, 2014) and Svensson's (2015) call for a more critical awareness of infrastructures and their implications in humanities research in general. The critique is more than timely at the time when new digital forms and formats of information from three-dimensional field documentation to digital objects and re-materialised artefacts and their preservation and archiving are central concerns of the field, but when much of the work is still been done on the level of building the technical rather than socio-technical infrastructures.

The essence of Svensson's (2015) and Huggett's (2016) concern is that on a profound level, in addition to supporting, facilitating, enabling and hindering information work, information infrastructures also shape what is recognised as information or knowledge (Bowker, 2005). In case of the large-scale (re)use of GIS data from earlier excavations, despite the brave efforts of individual researchers, the information is limited by that what is achievable to compile from earlier data sources. Similarly, when discussing the longevity of archaeological archives, the archived information is dependent on the infrastructure of heritage administration that both explicitly and implicitly determines not only the conditions of how and what becomes information but also indirectly, the information itself. The same applies to all infrastructures from museums to digital documentation technology. Platforms and infrastructures, both in their respective ways (Plantin et al., 2016), shape both the information itself, the premises of how it can be acted upon by acting indexically (Day, 2014) and what consequences the information has (Huvila, 2009). As Day (2014) notes, the work brings about vocabularies to express ideas, they function as cultural forms and social norms of what is 'useful' and they stabilise meaning in time. They not only act as indexes but are indexes and providers of social, cultural and physical affordances and constraints. The shared commitment to infrastructures in archaeology (Olsen, 2012) and in other disciplines (Bowker, 2005) are generative of not only objects and forms but as Olsen (2012) points out, on the level of ontology. Naming things not only changes their label but changes how they are perceived and acted upon, and eventually, what they are for us.

Ecology of information work

Even if there would be no reason to question the potential of the profound ontological impact of digital technologies, the empirical cases discussed in this volume – even if they undoubtedly provide us with only a very selective outlook

of what is happening in archaeological work – have conspicuously enough, underlined how the conduct of archaeology has changed, not that archaeology itself would have become something radically different. It might be relevant to ask whether the principal change has been, at least so far, an ontological or an epistemological one. The first impact of using digital visualisation at museums, three-dimensional documentation in the field and combining data from small scale surveys to large datasets is in how knowledge is being made rather than what the knowledge itself is. Both Dell'Unto and Löwenborg insinuate that new questions be asked by exploring three-dimensional models or by applying machine learning on archaeological big data, but rather than emerging out of the digital technology, it might be relevant to ask whether they would rather be an outcome of an evolving epistemological process.

The apparent resistance of archaeological work to bend to formalisations raises, however, a question of whether it is relevant to talk about archaeological processes or information processes after all. From the work of Gardin (1980, 1999, 2003) formally describing archaeological reasoning to more mundane efforts of describing various archaeological work processes in different countries (e.g. De Roo et al., 2016; RAÄ, 2015; Riksantikvarieämbetet, 2016), there has been many attempts to formally describe intellectual and practical processes in archaeology. The diversity of archaeological practices and the difficulty of these efforts to capture the details of the enterprise might sound like a reasonable justification for claiming that no such process exists. The examples discussed in this volume sanction the claim even if, as the texts of, for instance, Dell'Unto and Löwenborg show, there are local information processes, even if there is vari- ation, they are fixed to a degree. Processes and workflows are even more clearly visible in the archiving of archaeology in the text of Börjesson and Huvila. In this respect, it seems somehow plausible to claim that the archaeological information process does not indeed exist but there are multiples of both mature and rudimentary archaeological information processes, and even more impor- tantly, archaeological work is guided by an idea of processes. Even if the actual workflows are shifting, the idea of working according to a protocol and fol- lowing a process is in the heart of how archaeology is being performed and how archaeological knowledge is made. This becomes apparent in how archaeolo- gical work is documented in the field, how the documentation is archived and how the documentation needs to retain a reasonable degree of uniformity in order to be useful in local and global contexts. The idea of a process does not, however, necessarily correspond fully with the actual pace of action. The diversity of reporting and documentation and difficulties of bringing together larger sets of data suggest that the soft system of archaeological information work is closer to a mixture of individual and collective 'information journeys' (Blandford & Attfield, 2010) than following a formal protocol. As Greyson (2016) suggests of the evolution of information practices in time, the evolution of archaeological information work can also be described as a function of time, participants, settings and events. In comparison to contemporary processes, in archaeology, the time is long and the continuum of the constituents of

information work span from the events of the remote past to the future. Archaeology is beyond any doubt an example par excellence of situated action (Suchman, 1987) within which the situations are simultaneously local, global, contemporary and distant in time.

While the soft systems approach helps to understand the mangle of archaeological practices in systemic terms and gives a promise of being able to organise our explorations of them in a system that is capable of providing insights into the theory and practice of archaeological information work, the approach does only partially address the change of the systems. As systems theory in general, it is premised by substantialist rather than relational assumptions. According to general systems thinking, systems have a tendency to resist entropy and turn back to stability. They change in accordance with their internal dynamics and external influences and proceed to new states of stability. The internal and external dynamics of technological and social systems have been compared with evolutionary systems and the notion of ecology has been used both in a literal and a metaphorical sense to describe change in these contexts. The ambition of ecological metaphors has been to shift emphasis from the mechanistic views of social systems to a softer perspective, largely in parallel with the introduction of soft systems thinking as a critique of the earlier tenets of systems theory. At the same time, the notion of ecology is helpful in shifting the focus from conceptualising systems as essential entities towards understanding them from the perspective of process philosophy as patterns in the process of incessant becoming.

The concept of the ecology of information work (Huvila, 2006, 2009, 2011) is based on the ecological approach of Gibson (1979) as an ecological model to describe the dynamics of the co-evolution of information work and its infrastructures (Huvila, 2009, 2011). The central assumption of the model is that information infrastructures (the invisible substrate of information work) that function as a substrate for specific knowledge organisation systems (like information systems, models of classification) constrain or privilege particular ways of using information as a part of their daily pursuits, that is, engaging with information work, a sub- or meta-work related to all types of ordinary activities from professional leadership and teaching to carpentry, sports and collecting stamps. Correspondingly, specific configurations of information work warrant particular types of information infrastructures. Some of the characteristics of information work, namely, warrants (Howarth & Hourihan Jansen, 2014), can point to the same types of infrastructures but sometimes they can propound diagonally different approaches. Whether a particular infrastructure can cater for different warranting factors depends on its capability of incorporating new entities and relationships, or hospitality (Beghtol, 2002), as this capacity is referred to in the knowledge organisation research.

An adapted, somewhat simplified version of the ecological model is presented in Figure 6.1. Applied in the context of archaeological information work, the model suggests that specific models of documenting and communicating information lay foundations to how information is used in archaeological work.
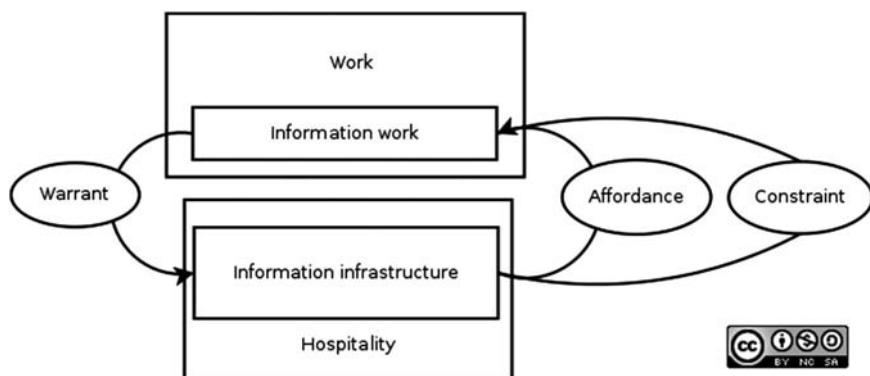
Figure 6.1 Ecology and warrants of information work and its infrastructures. Developed on the basis of an earlier model published in Huvila (2009).

Dell'Unto shows, in this volume, how new approaches to documenting in the field can pave the way for new approaches in analysing and interpreting the archaeological stratum. Similarly, according to the model, using the Gibsonian terms of affordances and constraints (Gibson, 1979), the infrastructures resist (i.e. constrain) the making of particular types of informational infrastructures and provide for (i.e. afford) the emergence of others (Huvila, 2009). In this volume, Löwenborg has illustrated how contemporary information infrastructures resist the ambitions to perform large-scale analyses and work towards archaeological big data, and what happens when, in the case of a machine learning approach, a solution from outside collides with data that is available.

The approach can also be paralleled with the notion of ecology of practices of Stengers (2005). Olsen (2012) has built on this particular notion while conceptualising archaeology as a discipline marked by its 'particular kind of care, obligation, and loyalty to things' (Olsen, 2012, p. 1). In contrast to Olsen, who delves in the theoretical foundations of archaeological work and its pursuit of mediating past and present, the emphasis of this volume has been more modest with its focus on archaeological information and information work. From a methodological perspective, Stengers makes an important claim of the need to define no practice like any other, which is also useful for the ecology of information work. Even if a specific practice, or work, has similarities with other types of work (or practices), it does not mean that in an inquiry of particular work, work could or should be equated with another. Information work should be approached where it diverges from other types of information work without 'insulting' (Stengers, 2005, p. 184) information workers and their perspectives.

In the context of our exploration to the realm of archaeological practices in the digital society, the model provides a framework to explicate the co-evolution of archaeological practices and digital technologies as their current and emerging (proto-)infrastructures. Similar to how Stengers (2005) and, for instance,

Hardin (2009) and Huvila (2012) building on the latter, have underlined the need to appreciate the fact that individuals have their rationale for doing what they do even if it is momentary and fleeting, we suggest that there are valid reasons why archaeological information work is conducted as it is done, and why it might and might not be necessarily very well aligned with existing infrastructures. We are not suggesting that all (digital) technologies would make an infrastructure but we posit that they have an infrastructural potential, a capability of becoming infrastructures or a part of them. As they become an invisible substrate of archaeological work, similar to how the road network, electricity, plumbing or the Internet are to the daily lives of most of the inhabitants of the developed world, a technology (whether it is digital archive, laser scanning or geographical information system) becomes or is absorbed into an infrastructure.

Making and taking information

Even if this book started with reference to a task of providing a better understanding of the archaeological information process, one of the most significant insights we can make by reading and reflecting upon the text so far is that there might not be a process after all. Or, that there are processes, but they do not link together to form a general process of how archaeological information flows from the field to the archives, desks of researchers, books, articles and museum exhibitions on another, at the most, highly abstract level. Or that it is possible to outline a process as, for instance, De Roo et al. (2016) and the Swedish DAP project (Larsson et al., 2017) have done but that the process is an abstraction that possibly hides as much as it reveals. The paradox is that an archaeological process can be convincingly, and for good reasons, defined as a crafted continuum of material worlds that spans from ruins and remains to their proxies (Shanks & McGuire, 1996), as an information flow (e.g. De Roo et al., 2016), or as labour used to turn archaeological imagination to texts, plans and documents (Witmore, 2004) – and digital data. As a whole, the intricacies of modelling the archaeological information process and determining how to appraise the model and its object is a reminder of the perplexities of models and modelling. Stengers (1997, pp. 95–96) argues that models can be essential to understanding phenomena, but they have a tendency to become that, namely, essential. Similar to publications, models and modelling are techniques of simplification (cf. Star, 1983) par excellence, which conceal complexity of work. In this respect, as contradictory as it may sound, a model of information work should be seen as much as a reminder to be critical of models of information work than a model itself.

Information is produced not only by professional field archaeologists and scholars but also by archivists, documentation and analysis technologies and the general public. Similarly, it does not flow from one individual or group to another, even if it is not inappropriate to argue that there is a process and continuum. In the mangle-like ecology of archaeological practices, it might be more appropriate to talk about an ecology of knowledge production, information seeking and situational appropriation of available information (Huvila, 2015), an

ever-changing soft system with temporary and similarly changing smaller and shorter local formal processes or systems of producing and supplying information for specific purposes and tasks. The introduction of digital tools in different parts of the system has changed the connections between established information processes, and expectations of how information should be searchable and usable.

In knowledge production, different actors are creating information that is being appropriated by others. Information seeking is characterised by a combination of purposive searching and encountering and production for an anticipated, in practice, imagined community of users, which partly is and partly is not anchored in the real needs and wants of actual users both at the present and in the future. Instead of imagining the process as a flow of information, it is posited that a better representation of the ecology of the archaeological information process could be a continuum of knowledge and information making and appropriation. A central advantage of this approach is that it explains why information flow fails without resorting to an explanation that frequent failures are an anomaly. They are a feature of the soft system and a reason why standardised catalogues are an attractive approach for solving information management problems, but tend to be a poor solution, especially from the perspective of users coming from different contexts and with different questions in their minds than those who created the standard and the catalogue. The approach also accounts why narrative (e.g. Boast & Biehl, 2011) and linear storylines (e.g. Vatanen, 2004) appear as useful in enhancing the flow of information, and why it is fully possible that archaeological work is both about revisiting knowledge (or documentation) about the past (Hicks, 2016) and 'past at the present' (Edgeworth, 2006, xi), a pursuit of acquiring knowledge from inside (Ingold, 2016) at the trowel's edge (Berggren & Hodder, 2003).

Figure 6.2 presents a sketch of an idea of how one actor makes information and how another takes it in and uses it. These links of making and taking form a practically infinite embroiled network of such connections between different actors. Taking is better seen as a form of appropriation than direct utilisation. It allows actors to use information in different situations in hand and make it useful from their premises now and here. Individuals and collective actors use
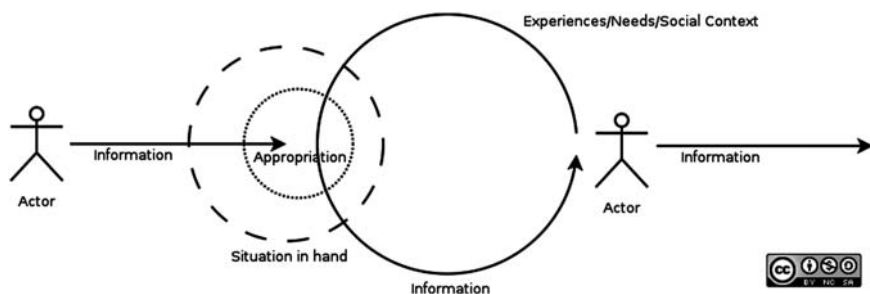
Figure 6.2 Making and taking information.

technologies to produce, change and access information, the situations take place in the different types of material, spatial and temporal premises, and are supported by informational and non-informational infrastructures that, for their part, are influencing and influenced by the actions of the involved actors.

Examples of this specific pattern of the relative disconnected making and taking of information can be seen in diverse contexts throughout the previous chapters of this volume. The most apparent is when information is produced by one actor and taken into use by another one in the context of development-led archaeology and the use of archaeological archives. A field archaeologist produces documentation with a certain idea of its possible use in the future, but both its longevity and usefulness for diverse purposes from administration to large-scale predictive analyses of settlement patterns is not directly embedded in the documentation itself but rather made at the moment when it is appropriated for use. Similar patterns prevail when archaeology is communicated to the general public. As Petersson with Larsson convincingly show, a museum makes archaeological information its own as a part of the process of producing an exhibition. The story told is not in field documentation, but it is made out of it and combined to information, which is similarly appropriated from other sources. The same pattern is discernible in Stenborg's chapter in how artefacts from a specific location are turned to a very different kind of information when they are placed in museum collections distant to the original context where they were found, and how these collections and their individual constituents are appropriated to inform actors close to their new home institutions and those coming from the area where they were discovered. Artefacts are engaged in an iterative process of making artefacts informative by originally creating them for their original intended use, disposing them, and unearthing, documenting and depositing them in museum collections. Simultaneously, they are engaged in a counter process of taking them into use both before their eventual disposal, and after their (re)discovery and inclusion in archaeological collections. There is no doubt that in the same way to how contemporary actors have widely diverging views of what these artefacts are and how they are useful, usable and informative, their past and future have had and will have a comparable variety of perspectives to the same question.

Even if the exchanges, the making and taking, are easiest to discern on the level of individual actors, in a broader scope, they are systemic like the archaeological information process as a whole. It is not merely individuals who make and take but (soft) systems that produce 'output', which is appropriated or taken by other systems, as illustrated in Figure 6.3. From this perspective, archaeological units, working groups, contractors, museums, community groups near and far, archivists, research teams and lines of inquiry, just to mention a few, are systems that make and take information. The information made by a single system can be taken up by a plethora of different other systems, which, for their part, make new information out of what they have taken, leading to an increasing proliferation of both information and what is known on the basis of an 'original' observation.
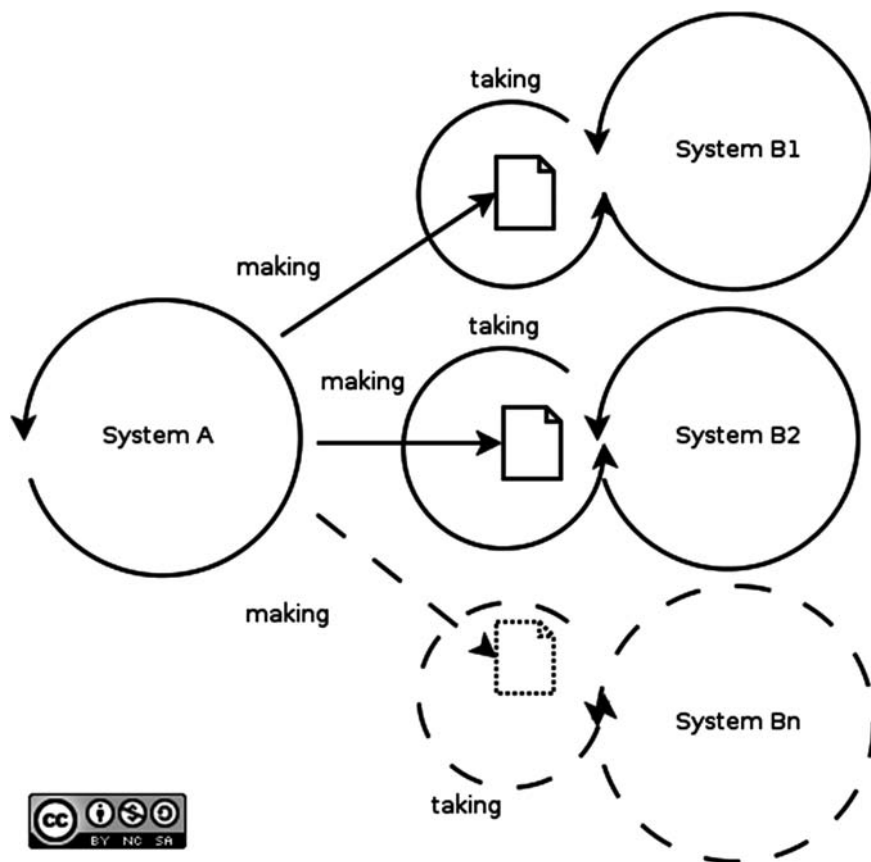
Figure 6.3 Making and taking on the level of interlinked (soft) systems.

Living with making and taking

It would be tempting to conclude this chapter by stating that archaeology is a complex constellation of practices. I do feel, however, that complexity is a bad conclusion, especially if the term is used to refer to a non-specific randomness rather than a specific form of meaningful, 'interesting' complexity (cf. Bawden & Robinson, 2015). At the same time, it would be equally tempting to repeat earlier observations on the nature of archaeological information work and to reconstitute the validity of the problems of organising archaeological information (e.g. Lavell, 1981; Oikarinen & Kortelainen, 2013). There is no doubt of the validity of this observation, but it does little to help us understand the intricacies of archaeological information work, and when turning to the next chapter of this book, to explicate how archaeology changes in the digital society.

The current chapter has described archaeology as an intertwingled ecology of practices rather than a linear or quasi-linear process. However, rather than portraying this ecology as utterly rhizomatic and convoluted, there is a great deal of systematicity and patterns both on the level of ideals that ushers the imagination of archaeologists and other stakeholders of archaeological work, and in the practices themselves. Further, as the brief excursions to diverse instances of archaeological practices and information work have shown, doing archaeology is situated and premised by a complex set of infrastructures each with its particular affordances and constraints that permit and impede specific approaches to how archaeology is carried out. Doing archaeology and working with archaeological information are not as much a flow as it is about how information is made and taken in diverse situations and contexts and how infrastructures of archaeological work afford and constrain these activities.

Instead of attempting to formalise the soft system and its information flows in their entirety, it would seem that the most plausible approach for trying to make sense of the system, and how it changes, is to follow the local practices of information work, identify their stakeholders and the stakeholders' worldviews. The current unspecific focus of the producers and curators of archaeological information on future research as the major stakeholder of archaeological information should be replaced by a more explicit consideration of what the research might be and what the researchers could and should be focussing on. Simultaneously, both the producers and users might benefit of thinking themselves as stakeholders and potential users of the information they are producing, and being more explicitly present in the information they are producing. Living with making and taking means that the disconnect needs to be taken seriously and accepted as a part of the ecology of archaeological information work. Living and accepting does not equate with giving up the attempts to make information as takeable as possible, or to try to take it as closely as it was made whenever possible and useful. What it does mean is that there is a disconnect that has to be acknowledged, taken into account and made explicit every time it happens indifferent of the context where archaeological information is made or used, be it in scholarly research, while telling the general public about an archaeological site or when deciding whether to give a go-ahead for a construction project.

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7 Archaeological information work and the digital turn

Isto Huvila, Lisa Börjesson, Nicolò Dell'Unto, Daniel Löwenborg, Bodil Petersson and Per Stenborg

Introduction

The discussion in this volume so far has brought forward examples of how the digitisation of archaeological information practices changes archaeology. As Dell'Unto demonstrates, it has an impact on what and how archaeology can document objects, features and processes it is interested in. Furthermore, as Börjesson and Huvila suggest, it can also change the premises of what and how information can be organised, managed and preserved, and eventually sought and used, as Löwenborg discusses in his work. Additionally, as Stenborg, and Petersson and Larsson illustrate, digitalisation has a capability to transform the outcomes and impact of archaeological work. After traversing through these themes, this final chapter brings together themes discussed in earlier chapters and outlines the impact of digital technologies and 'the digital' on the archaeological information process, and seeks to identify how and when digitisation influences the practices of using, producing and managing information.

The digital turn

An obvious question that stems from acknowledging temporality and the change of situations as a constitutive part of the archaeological enterprise is how change and continuity are premised in the process. Even if it might be tempting to claim, based on the examples, that the 'digital' has turned archaeological information work into a new digital archaeological information work, it would be a too simple an explanation. As Galloway (2014) notes, similar to seeing digital as an object, the digitisation of a field of inquiry, such as conveying a new discipline of digital archaeology, misses an important point – even if it the point would be other than his non-philosophical perspective on the digital based on the work of Laruel. An outcome of such an externalisation of a digital turn would be the institutionalisation of the binary of digital and non-digital, or as it is often problematically portrayed (Boellstorff, 2016), between digital and real.

Even the impact of digital technologies on archaeology has often been described using strong adjectives. Zubrow (2006) and Díaz-Andreu (2017) write about 'digital revolution', and, for instance, Dell'Unto and colleagues write about

'radical change' (Dell'Unto et al., 2010). Others (e.g. Boast & Biehl, 2011; Kristiansen, 2014a) see the digital shift as an aspect of a broader paradigmatic or methodological change. At the same time, however, many researchers have remarked that there is much subtlety in this purported paradigm shift. The claim that 'we are all digital archaeologists' (Morgan & Eve, 2012, p. 523) is equally valid than it is of dubious value to essentialise digital archaeology or being a digital archaeologist. Post–digital–turn–archaeology is evidently a mixture of 'old' analogue and 'new' digital archaeologies (Olsen, 2012). Dallas (2009) also notes importantly that the digitisation of archaeological heritage is only a part of the 'dramatic shift' that has taken place since the 1970s. A myriad of changes, including the increasing involvement of new stakeholders from computer and information scientists to anthropologists, has played a significant role in the process. There is indeed a reason to be critical of suggestions of an on-going paradigm shift (Gordon et al., 2016), where and what is changing and causing a change and whether there is convincing evidence available. Even if digital technologies have many evident opportunities of influencing archaeological and information work, it might not be altogether clear where the 'real' change takes place. Stenborg notes aptly in this volume that the digitalisation of archaeological work has coincided with an accelerating destruction of archaeological sites around the world.

As Shott (2014) remarks, archaeologists have already been using digital data for a couple of decades. Therefore, it might be an exaggeration to talk from an overarching perspective about a revolution here and now. Similarly, even if digital tools have had a major impact in data capture both in the field and in laboratories, archaeologists have captured data before. Of course, it would be unfair to trivialise the direct practical impact of digital technologies. First, as the ecological perspective anticipates, and the different examples discussed in this volume suggest, archaeology is literally done, and as a system it is 'becoming' through a mangle of different large and small practices. A museum exhibition, archaeological archive or three-dimensional field documentation does not emerge out of nothing but are an outcome of a complex socio-material processes. Second, even if the daily interactions with digital technologies might appear as only partially meaningful routine work, they take up a large part of the working time of present day archaeologists. But still, there is a good reason to bring more introspection into digital archaeology as Huggett (2015a) urges, starting from questioning its role as an auxiliary discipline or a fundamental aspect of archaeological thinking (e.g. Cortese, 2016) and its compatibility with the epistemological underpinnings of archaeological work (cf. Kay, 1995), but not ending there, and not separated from the elucidation of the mundane practices but to complement them to see the outcomes clearer of these often somewhat technical shifts of everyday work. Eventually, they have an impact on the analysis of observations and materials and the making of archaeological knowledge. It may seem subtle (Shott, 2014) and it can undoubtedly be difficult to pin down (Huggett, 2015a).

The accounts of how digital technologies have penetrated archaeological practices convey a story of change, but it is also rather apparent that the change

does not apply as much to the intellectual and theoretical aims and underpinnings of archaeological work and information work than their practical premises. The multitude of examples throughout the chapters of this volume reasserts Olsen's (2012) thesis that archaeology is still a discipline of things. Archaeology deals with material remains of past peoples, societies and cultures (Drewett, 1999), and simultaneously it is 'a strange mixture of scientist and science and storyteller and narrative reconstruction' (Zubrow, 2006, p. 8), and a form of political action (McGuire, 2008) rather than a digital thing. In spite of the perseverance of many of the fundamental underpinnings of archaeology and archaeological information work, and the occasional elusiveness of the digital turn, many aspects of archaeological information work have indeed changed, and as, for instance, Cortese (2016) and Dell'Unto (this volume) remind us, it is important to keep epistemological reflections and technologies close to each other.

Without attempting to provide an exhaustive account of everything, it is obvious that there are some themes that have recurred in this volume from one chapter to another. Without exaggerating, it is fair to claim that the infrastructures of archaeological information work have changed. Digitisation has also had an impact on the rudimentary practices of how archaeology is done, or in more general terms, how archaeology is achieved. Further, the topology of how archaeology is organised in space and time has shifted, and finally, even if the evidence was not conclusive, it is necessary to take seriously the question of whether the archaeological information itself has changed.

Infrastructures

To start with, it would be difficult not to put emphasis on how all the previous chapters demonstrate the change of the infrastructures of archaeological information work. Some of these sub-structures are emerging such as digital repositories for archiving and accessing archaeological data for large-scale analysis. Some of them are national and generic to all archaeological (field)work like the UK Archaeology Data Service (Beagrie & Houghton, 2013) or DANS (Palaiologk et al., 2012) in the Netherlands, but many of the infrastructures are more specific and local to specific conditions and needs like the ones developed by the authors of this volume for the specific purposes of particular field projects and research questions. Also, very generic technologies and movements such as the nearly ubiquitous availability of portable (digital) computers and handheld devices, or such movements as open access publishing and open data have infrastructural qualities and provide a substructure to contemporary archaeological work. The currently emerging small and large repositories and laboratories are already functioning as an infrastructure for some archaeological activities and as Löwenborg and many others point out (e.g. Aspöck & Geser, 2013; Richards, 2006), there is potential for more. Even if these changes may seem as diffuse and non-specific as they have been portrayed in the different chapters of this book, the principal locus of change may well lie precisely in these subtle changes rather than in major national and international initiatives. The shape of infrastructure changes

every time the distribution of power changes, and new ideas are imported into them, as Strathern (1995) reminds, not only when it is faced by a dramatic metamorphosis. In a heterogeneous enterprise like archaeology, the number of these shifts make them difficult to trace but at the same time, potentially much more potent than large more obvious changes.

Some of the infrastructures and infrastructural practices, such as archaeological report writing, are resisting change (Huvila, 2016b). Some, like soil, which is an infrastructure par excellence for archaeology, are not going to change even if, as Dell'Unto demonstrates, they can be reframed, repositioned and transformed in archaeological work by the use of digital technologies. Soil can be many things. It is a particular type of material information infrastructure for non-digital archaeological work, but in a broader sense, a bio-infrastructure accessed by myriad ways of conducting research, gardening, cultivating, composting and building (Puig de la Bellacasa, 2016). Digital technologies allow new kinds of archaeological approaches to access it and the information that may come about when someone is working with it. At the same time, it is obvious that the digital is not a universal key and to a certain extent, it is only healthy if the digital turn will be followed by a relative 'post-digital' reemphasis of analogue techniques (Selwyn, 2003; Thorén & Kitzmann, 2015) that would contextualise different techniques in the context of each other.

In contrast to infrastructures and premises that are emerging, some of the digital sub-structures of doing archaeology are definitely there and their effects are profound, but they can be difficult to pin down. Petersson shows in her chapter how diffuse the impact of digitalisation can be to storytelling in museums. The impact of 'the digital' becoming a new default in society (Huvila, 2012b), an outline and a yardstick of how things are supposed to work, becomes difficult, if not impossible, to say what the direct impact of digital technologies, digital ideologies and their repercussions are when filtered to specific areas of life and work through their broader social and cultural contexts. As a societal phenom-enon, digitalisation can be described as an exogenous shock (Morville, 2014) for archaeological work that comes from outside and forces archaeology to adapt. At the same time, as an infrastructure, it can function as a yardstick to compare and critique and point to the inadequacy of long-held views on archaeological practices (cf. parallels in archival studies, Hand, 2008), revealing the contem-porary condition of archaeological information work. In this respect, one of the most apparent infrastructural peculiarities is the assumption underlying, in practice, all contemporary efforts of managing archaeological information that such information as archaeological documentation would keep the same characteristics over time. As the different excursions, albeit brief and few in number, in this volume have shown, there is little linearity in how archaeology works with information. There is always a gap between the one who makes information and the one who takes it. Even if they would be the same person, the situation would be different. Similar to the false expectation of changelessness, its opposite can be equally dangerous. With the constant increase in the specificity of documentation methods and research questions, there is a real risk in ending up in

a situation where information becomes unintelligible. The question posed by Löwenborg on how to make infrastructures useful is a crucial one. Both he and Stenborg underline the importance of standards as enablers of interoperability of collections and clean data. However, as Börjesson and Huvila underline, there might be problems in the current assumptions of how and what to standardise for ensuring the longevity of infrastructures and information.

However, in contrast to the rather obvious infrastructural impact of the explicit technical digital sub-structures of archaeological work or the repercussions of the largely implicit digitalisation of societal assumptions and defaults, the most pertinent question of the impact of changing infrastructures for archaeological information work may lie elsewhere. The question is whether the digital changes the deeper infrastructures of the infrastructural landscape, which are underlying the conceivable sub-structures and assumptions of how archaeology is done. None of us who have contributed to this volume have made a claim for this kind of shift. The digital might not, at least not alone, be enough to stop archaeologists excavating or collecting; turning archaeology from a discipline of things to a discipline of data, to turn its primary focus from the past to the future (acknowledging that archaeological methods are being used to investigate contemporary phenomena and to inform future plans of action, e.g. Holtorf, 2012), or to solve the age old debate of the appropriate degree of how much archaeology should be concerned in collecting and how much in interpretation (cf. Andrews et al., 2000). The value of considering such largely hypothetical infrastructural possibilities might not be in the likelihood that they would realise, but rather in how it leads to the consideration of the relation of infrastructures, digitalisation and other facets of archaeological information work.

Achieving archaeology

In addition to its infrastructural premises, digital technology and the digital are also affecting the conduct of archaeology. As a part of everyday practices of archaeological work, this is apparent in the emergence of new routines of work and the use of new tools. These are obvious throughout this volume. Löwenborg describes the opportunities of using mass data for asking new questions and pursuing new answers. Dell'Unto and Stenborg point to similar possibilities with different types of three-dimensional representations, and Petersson points to how a broad variety of digital technologies can change how the impact of archaeology is realised in a societal context in museum exhibitions. On a more profound level, the digitalisation of information, as Olsen (2012) proposed, affects how data and the past are achieved. Digging even deeper, the influence of digitalisation does not stop at the level of achieving instead of archaeology but in archaeological work itself, including the invisible work with archaeological information. As Olsen notes by referring to the notion of Latour (1993), the 'infraphysics' of digital media is different. The digital does not only provide opportunities but makes us to do things differently, as the examples discussed in this book from field documentation to museum work show. The new data collection methods in the

field from 3D acquisition to a more mundane use of databases for recording finds and observations change how information is collected, preserved, mediated and used today, and what are its prospects of longevity in the future. The emerging research on the reuse of archaeological data has pointed both to opportunities and difficulties of achieving the valiant objectives of the open data movement (Faniel & Yakel, 2017; Faniel et al., 2013). As Löwenborg's work shows, there is still a lot of work to be done before the archiving of archaeological information is genuinely capable of facilitating the reuse of data for research and other purposes. There is a need for more empirical research on reuse, documented case studies of both successful and unsuccessful reutilisation of archaeological information and an in-depth theoretical understanding of what reuse does to information, and how and what implications it has on archaeology – the interpretations of the past. Like in the sciences in general (Bowker, 2005), digitalisation has brought a profound change to the memory practices of archaeology, and even more so, to conceivable practices of how archaeology can remember through a nexus of extreme heterogeneity and standardisation. However as, for instance, Löwenborg's text and the progress in semantic processing of archaeological grey literature (e.g. Vlachidis & Tudhope, 2015; Vlachidis et al., 2010) show, the contemporary memory practices, their affordances and constraints as a whole, rather than a specific technology, dictate the premises and realities of archaeological (information) work. It is not information (or data), its methods and infrastructures, or the practices of working with information alone that dictate the outcome but the (soft) system as a whole. Here, a parallel reading of the texts of Löwenborg and Dell'Unto can give a hint of the complexities of combining the best of the both worlds, even if doing that, as Cooper and Green (2015) justly suggest, would be an ideal course of action. Digitality allows individual archaeologists, amateurs and, for instance, actors in the development-led archaeology to act as collectors, a peculiar role that previously had shifted from being a private enterprise of upper-class individuals and academics to a public monopoly. However, even if different types of digital information can be put together, copied and distributed unlike any analogue information, its digitality is not a guarantee of its fertility, transparency and the preservation of the traces of its origins, engagement and participation as the multiple constraints pinpointed by Börjesson and Huvila, Stenborg, and Löwenborg suggest. The potential is there as earlier literature has been keen to highlight (e.g. Olsen, 2012; Richardson, 2014) but it is not there to be taken for granted. There are multiple opportunities as, for instance, Olsen (2012) has suggested earlier, and those highlighted by the authors of this volume, but they are not only dependent on how digital technologies are applied in the context of archaeology but as much on how archaeology resists or pushes back (cf. Pickering, 1995) against the digital. Why this might be exceedingly difficult, as Stenborg notes earlier in this volume, are the expectations of efficiency, increased productivity and lower costs so closely attached to the introduction of digital technologies. It is not easy for archaeology to resist the affective assumptions of easiness and efficiency that has begun to underpin general assumptions of everyday information work, especially in the

search of information online (Huvila, 2012b, 2016a). The focus on gathering data in (often relational) databases (Fuller & Goffey, 2012; Gugerli, 2012; Huvila, 2012a) and analysing it algorithmically as a part of a new archaeological paradigm (e.g. Kristiansen, 2014a; see also Löwenborg, this volume) turns the past human beings to 'quantified them', past versions of the contemporary quantified selfs (Neff & Nafus, 2016) that are more meticulously documented, and to a certain extent, more present in the data-sphere than through the physical evidence of their existence. Simultaneously as the privileged frame of working with information about the past turns to a digital one, archaeological work of how archaeology is achieved becomes digital. Even if it might sound contradictory, archaeological work can become digital even if the discipline itself would remain, citing Olsen (2012), that of things.

Topology of archaeological information work

In addition to affecting the premises, infrastructures and practices of achieving archaeology, the digital is affecting the topology of archaeological information work: how its different human and non-human constituents are connected and related to each other. Börjesson and Huvila describe meticulously how the organisations and reorganisations of development-led archaeology has changed the roles and responsibilities of different archaeological actors, and how, to a certain extent, the archaeological landscape is still very much in the making. A large part of the problems of accessing archaeological primary data currently held by a myriad of actors in Sweden, as the situation is described in the chapter of Löwenborg, can be traced back to the friction between how the existing legacy structures are organised and what type of topology would be useful from the perspective of digital tools and data. Topological aspects are also highlighted in the texts of Petersson and Larsson, and of Stenborg. Digital technology is changing the expectations of how museum space is organised and how archaeologists, visitors and museum professionals are connected to each other. Stenborg describes a similar change on a local and a global scale. How digitality changes the social and geographical access to artefacts and makes them not only accessible but usable in different terms than they have been before. He is optimistic on the democratic potential of the Internet but emphasises the need to actively act for its continuing openness. In Stenborg's examples, the changing topology is, however, as much social as it is geographical. It marks a general shift from consulting to collaboration (Zimmerman & Branam, 2014), and the introduction (Huvila, 2016a) and practical impact of digital technologies in not only intensifying but also changing the landscape of working together with the stakeholders of archaeological work.

In addition to changing the topology of engaging with archaeology, the digital also changes the prospect of archaeological information. Löwenborg criticises the tendencies to overemphasise the uniqueness of archaeological sites and the reluctance to strive for inclusive and flexible documentation. The changing topology of archaeological information work also means that it will be increasingly

difficult to make such claims of distinctiveness. At the same time, in cases when such claims are feasible, they can and have to be made from different premises. A possible alternative to trying to balance between two essentially irreconcilable needs could be to cater for the contemporary and anticipated future needs as two parallel pursuits. A part of the effort could be directed to serving immediate needs and interest where a part would be focussed on the longevity (as in Börjesson and Huvila) of data and its usability in aggregated analyses (as for Löwenborg). Studies show that digital access to scholarly information has changed scholarly information practices across the disciplines (e.g. Borgman, 2007; Rowlands & Fieldhouse, 2007a, 2007b), and similar to how it has already changed, with useful infrastructures to support scholarly work, could change how scholars manage information (Trace & Karadkar, 2017). Easier access to older and geographically remote materials make them easier to cite and use, a tendency that is also apparent in the chapters of Stenborg and Löwenborg. The changing topology of archaeological information work also means changes in the topology of archaeological information. Information that previously has been remote and difficult to access becomes closer, but also vice versa, if closely located information is difficult to access and use for different reasons. Incompatible file formats as Löwenborg has experienced, or copyright issues, are merely a couple of examples of how shifting topologies might affect its usability and longevity.

Brave new information

Probably the most contentious question is whether the digital turn would also come with new information. The shear amount of new archaeological information, or data, highlighted in this volume by Löwenborg warrants the claim that there is indeed new information even if it might not be altogether clear how much of this new information is new and how much of it is actually more of the same. Before, apart from a selection of artefacts that were preserved as such, much of the archaeological information were interpretations, whereas at the present, there is an increasing strive towards ensuring the longevity of less processed data. Also, observing in practice in contexts ranging from archiving and landscape research to museums and fieldwork, shows how knowledge-making is indeed political in how it is not only about making propositions and suggestions but ontologies (Nickel, 2015), which means that the very activity itself is generative of new knowledge and information.

Another way of formulating the question is whether there are new types of information that would be useful for the archaeological discipline. In general, there is no doubt that this would happen or that it would be a specific feature of digital technologies. Since the advent of archaeology, new methods from typological classification to scientific dating and elementary analysis have opened new sources of information for archaeological inquiry, and theories have introduced novel perspectives to seeing old things inform in new ways. Different stakeholders of archaeological interesting sites and objects have also had diverging ideas of whether various things can be classified as archaeological

information or if they are a part of completely different typological regimes. Indigenous artefacts and human remains tend to have been among the most debated types of things (e.g. Grose, 1996). Even if the status of digital things is not necessarily as contested as that of physical remains or landscapes, asking whether and to what degree, a (digital) photograph or (digital) spatial coordinate are new information when compared with non-digital ones – whether the digital things belong to the realm of the digital, or to those of photographs and spatial coordinates.

Huvila (2014) has suggested earlier that much of the paradigmatic development in archaeology could be explained by the availability of new (types of) information. Kristiansen (2014b) dismissed this idea by reminding us that paradigms have always been associated with new theories as well. His emphasis of the significance of theory in the formation of new paradigms or intellectual movements within scholarly disciplines is undoubtedly correct but it might be too hasty to discard the role of new information altogether, especially without thoroughly considering the links between theories, technologies and 'new' information. Even if theory guides inquiry, use of technologies and insights into what is informative and how technologies also give access to (new types of) information and (new types of) information informs theory formulation. Theories do not emerge *ex nihilo*. They are based on knowledge and information. The main success of the long-standing but largely somewhat sporadic debate of the possible theoretical underpinnings of digital archaeology (e.g. Huggett, 2015b; Wooldridge, 2013; Zubrow, 2006), including virtual (Forte & Beltrami, 2000) and cyber archaeologies (Forte, 2010), has probably been to show that the existence and use of a certain constellation of technologies alone is a problematic basis for theory formulation. In contrast to the technical possibilities of new tools, there has been considerably less discussion on what (information) and how (roughly, theory) they contribute to the making of new archaeological knowledge.

Even if some scepticism of whether the digital turn comes with new information is warranted, this volume has suggested that at least, in some cases and to a certain degree, this may be the case. Löwenborg describes how the meagre results of small excavations can contribute to new knowledge about the human past when they are pooled together. Also, Dell'Unto makes a strong case for three-dimensional modelling leading to new information and new insights about the past. They both could represent something geographer, John Pickles, has described as new cartographies in the context of archaeology, new 'mappings-in-depth' (Pickles, 2003, p. 21) of topics of particular archaeological interest. However, the danger of making inflated claims of the power of new methods, approaches and technologies to yield new information is present even with the digital methods in archaeology. Even if some of the data has been there, perhaps inscribed half-hidden in paper documentation, the possibility of digitising it and complementing it with an increasing repertoire of digitally captured numeric and visual data takes archaeologists closer to a situation where it is possible to go back in the information process and try to reanalyse data and consider the plausibility of alternative conclusions. Earlier, this was possible

almost only with finds that were the only part of surveyed and excavated sites preserved as such. The claims that this new information allows archaeologists to redo excavations should be dismissed as wishful thinking but re-examining them as Dell'Unto (this volume) and other researchers (e.g. Powlesland, 2016) have suggested, certainly becomes possible to an extent that was impossible before.

A relevant, simultaneously apparent and difficult, question posed by the critics of mainstream digital archaeology (Morgan, 2012) and the use of digital methods in humanities (e.g. Allington et al., 2016; Kirsch, 2014) in general, is whether these possibilities have actually helped researchers and others to create substantial new knowledge. In a sense, the algorithmic methods hold a promise of turning earlier 'noise' (Parmiggiani et al., 2016) into meaningful information. Even if the documentation was there, the information is new. From this perspective, the informing potential of this type of mass data is classable, using the term of Orlikowski and Scott (2015), as an algorithmic phenomenon that would not exist without digital technologies and imagination. Here goes undoubtedly the fine line between when it is appropriate to talk about new information and when the shift pertains to the choice of how the discipline prefers to inform and get informed. Instead of remaining as a question of new and old information, the latter turns back to the question of how a discipline is achieved and whether either 'information' (cf. Kay, 1995; Srinivasan et al., 2017), or lately, even more so, 'data' is becoming the new determinant of how archaeology is accomplished (Borgman, 2015; Kristiansen, 2014a; Meyer & Schroeder, 2015).

A parallel question to the emergence of new information for archaeological inquiry is whether the digital turn comes with new information that can be informative for other stakeholders of the archaeological enterprise. As Stenborg emphasises, the argument that the significance and meaning of information in general and with specific objects differs in the social and cultural background of their spectators is strong and this social life of information (Brown & Duguid, 2000) has direct consequences on the novelty of archaeological information (Boast & Biehl, 2011). In this respect, much archaeological information is somehow new or, at least, has the potential to provide new insights if it is properly contextualised and communicated in a form that makes it accessible.

The same applies to information that is not there. Löwenborg notes that information about the lack of information, the archaeological emptiness of a particular area, is probably the most important piece of information for a land developer, but it is also useful for archaeological research even if, from the archaeological perspective, the current lack of remains does not necessarily equate with emptiness in the past. Similar to Löwenborg, Petersson and Stenborg both demonstrate how digital technologies can help connect individuals with information that is new to them, something they have not been able to experience before because of the lack of possibilities of connecting with it due to geographical, temporal or cognitive distance. The examples show that even if the longevity of archaeological information is one of the most crucial questions in archiving and preserving archaeological information, it is also pertinent to other types of distances whether they are spatial, social or individual. Leaning back to

how Huvila portrays archaeological information work earlier in this volume, it could be argued that because of the perpetual making and taking, there is something new in all archaeological information all the time. The novelty of information is not only characteristic to digitalisation but to the very act of working with archaeological information. The digital turn comes with an impact, but it is only one of the many and real challenges in understanding how much of the change depends on digitalisation and what are the things that should be attributed to everything else.

Explaining the turn

After claiming the premise and infrastructures of archaeological information work, the process of how archaeology is achieved, the topology of archaeological information practices, what is considered to be archaeological information and what things are informative of, and for, archaeology changes, an obvious question remains, whether and how these different shifts and oscillations are related or unrelated. This excursion to the intertwingularity of archaeological practices and information work have shown that even if it might not be wrong to refer to a paradigm shift, there are nuances in the influence of digitality. It has idiosyncrasies of a paradigm, but it also has characteristics of a social intellectual movement, a collective effort 'to pursue research programs or projects for thought in the face of resistance from others in the scientific or intellectual community' (Frickel & Gross, 2005, p. 207). Rather than being abrupt, in archaeological knowledge-making, the digital turn seems contentious, political and conditioned by a particular constellation of material and conceptual resources, tools and collective action (cf. Sheble, 2014). Our proposal is that in the context of archaeological information work, digitality itself does not have a direct impact on the making of the grand and less-prominent narratives of archaeology on the understanding of social organisation or the landscapes of the past or such issues as memory, time, gender or identity. The digital itself does not make archaeological information work to become something else. Its impact comes from how it affects the premises and infrastructures of archaeological information work, its impact on how archaeology is achieved, how it influences the topology of archaeological information work and through its repercussions on what is considered to be archaeological information. This does not imply that digital technologies would be neutral or without a certain agency of their own. They do have an impact on what archaeology is and what it becomes. They do indirectly privilege particular research questions, alleviate old and create new inequalities and oppress opinions and perspectives by their presence and absence, as well as the presence and absence of opportunities and competences for engaging with digital technologies and digital information. An important next step after the discussion in this volume is to engage with the theory of the digital in, and for, archaeology.

One possible approach to explaining how digital technologies are changing archaeological work is to turn to the concept of *lieux de savoir* (Jacob, 2014). Jacob

describes it as a spatial and mobile place where knowing happens. Instead of claiming that the major impact of digital technologies would be on the knowing itself, we are inclined to suggest that much of the most prominent changes discussed in this volume, and in the earlier literature, can be plausibly explained by a change of where archaeological information work takes place and where knowing about archaeology takes place. Similar to how Berggren and Hodder (2003) have suggested that one of the foundational principles of reflexive archaeology is that interpretation should take place at the trowel's edge, and Dell'Unto writes how 3D technologies have the potential to become a new trowel with a new edge, other stakeholders of archaeological information have their trowels that are changing, and that are changing the *lieux* of the ecology of information work. Even in Löwenborg's discussion of the possibilities of applying machine learning in the context of archaeology, and earlier examples in the literature (e.g. van der Maaten et al., 2007), for instance, on automatic classification and retrieval of artefacts, the major change is not how knowing happens but that it happens in a digital, social and material *lieux de savoir*. The same observation applies to Dell'Unto's use of digital tools for explicating excavation contexts. The primary change might not be in that knowing changes per se but that the locus of that activity changes form. Stenborg shows further that the *lieux de savoir* not only changes within a particular context of archaeological work but also widens to comprise additional perspectives and groups of people.

A part of the usefulness of the notion of *lieux de savoir* is in its spatiality that allows the bringing together of human and non-human things in overlapping, partly connected and disconnected constellations. The second equally pertinent aspect is their temporality. They can be (nearly) permanent, durable or fleeting. Even if Jacob seems to have been sparse in making direct references to ecological thinking, they are ecological in a similar sense as information work is. Pearson and Shanks (2001) remind us that digital media are socio-technical (and socio-material) networks that make archaeology for us and, further, as Olsen (2012) continues, digital heritage (and archaeology) consists of events underway. Similarly, the digital itself is fleeting, and instead of talking about one digital turn, the digital turn constantly makes and remakes (digital) archaeological information work on and on again.

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Epilogue

Isto Huvila

This volume began with the somewhat bizarre proclamation that there is no digital archaeology and no digital society. There would be merely archaeology and society, and that digital was simply a facet of a particular set of technologies and a cultural phenomenon that permeates contemporary existence both when it is present and when it is absent. From this initial claim, this volume has oscillated between denial and affirmation that digitality still might hold at least a semi-privileged position in the making and becoming of archaeological information and knowledge.

There is no doubt that changing information and changing the premises and practices of conducting archaeological information work is shifting the way in how archaeology is done and when archaeology is done. Embracing digitality is to a large degree a question of competence of critically understanding a branch of technologies, their use, usefulness and direct and indirect cultural reper-cussions. It is fair to claim that both quantitatively and qualitatively, there is more archaeological and archaeologically relevant information than before and new copious possibilities to use and reuse, analyse and reanalyse this infor-mation. At the moment, the downside of many of the possible futures is that they are still on the level of ambitions, aspirations and visions rather than reality. Some of the impediments are undoubtedly solvable whether they are practical or organisational. To a certain degree, it is possible to complete unfinished information and fill repositories, reuse data, test untested instruments and techniques and develop the organisation of archaeological work. What is impossible, however, is to make information informative beyond its limits, or to use it without a theory of how to 'take' information that is out there within the limits of how it was 'made'. This applies to the paradigmatic development of archaeological research as much as to the aspirations of borrowing methods from fields working with highly standardised datasets, such as demographics and economics, to archaeology, where there is no feasible way of trying to stan-dardise what emerges out of the stratum. The antithesis, an extremist post-modern assumption that all information is essentially untakeable, is, however, equally problematic, and might lead to radically context-over-dependent and local knowledge-making. Paraphrasing the remark of Ley (2003), local is an uncomfortable category in the context of archaeological information work.

There has to be larger categories to manage practical issues on the level of a discipline even if localism and pluralism are their key ingredients.

The tension between the local and the global also obviously pertains to our observations in this volume. The limitations of our largely Scandinavian perspective and of the themes (not) covered in this volume come with their own localities, and the general remarks and interpretations are conditioned by the contexts from where they stem. Yet, the particular frames of working with specific types and pieces of information should not stop us or anyone else exploring and striving for a broader common ground. A vital aspect in the process is to maintain a critical sensitivity to the limits of both large and narrow categories and an understanding of their consequences to archaeological information work and the conduct of archaeology. This is a task of all archaeological information workers from field archaeologists to GIS specialists, curators and information managers, and obviously, especially those who are engaged in educating and training future generations of professionals.

Another dichotomy, the relation of whether archaeological information work should be (primarily) about collecting or interpreting, is not directly attributable to the emergence of the digital but is essentially another aspect of the same question of explaining and framing the purpose of information and information work in the context of archaeology. The particular antagonism between the 'passion for collection' (Shanks, 2012) and a strive for interpretation (e.g. Andrews et al., 2000), together with a wealth of other binary oppositions (Thomas, 2004), have been, and is still, characteristic to both archaeological literature, and as Börjesson and Huvila show, the politics of managing and conducting archaeology. As the chapters of this volume demonstrate, digital technologies have, in general, made the most formidable impact on collecting, whereas the challenges and doubts described throughout the text tend to relate to the questions of use and reuse of data, how to interpret digital data and whether, how and when digital methods have helped to make any significant contributions to archaeological interpretation. A part of the problem is that collecting is easier to measure and link to the use of specific tools and instruments. In contrast, it is difficult to verify whether a particular interpretation would have been impossible without a certain type of (digital) data or a specific (digital) instrument. Another, even more pertinent, part of the issue is that the paradox is deeply rooted in the very fundament of how archaeologists work with information. Collecting is an essential part of the making of information, whereas information taking builds on interpretation. This contrast of making and taking is also visible in archaeological (information) policies that tend to instruct information making from the perspective of a taker, which emphasises the ideal of selectiveness and usefulness of archaeological information, whereas everyday practices of documenting archaeology in the field and elsewhere take the maker perspective and emphasise the ideal of completeness and the impossibility of anticipating the needs and wants of future information takers.

In the end, the question of whether there really is no digital archaeology and no digital society is a question of the privileges given to the digital similar to how

the primacy of collecting or interpreting is a question of their order of ascendancy. There are no doubts that we are heading towards a post-digital (as for Brattli, 2016) archaeology and archaeological information work in society, which is more digital than ours but marked by another paradigmatic discourse. Whether it will lead to a true shift of what is considered as 'normal science' in archaeology remains to be seen. Risking the accusation of cherry-picking remarks rather than discussing the substance, it seems that there is reason to agree with Galloway (2014) because from the perspective of archaeological information and knowledge-making, it is problematic to take the digital in archaeology as an object of study, or 'digitising' archaeology, as they both easily fail to capture the ontological and epistemological facets of digitality. Digital things are not substitutes for non-digital things if they are not given prerogatives to be that and are freed from the demands of upholding parallel digital and non-digital practices. Simultaneously, even if there is no doubt that information and information work would not be the power, it is not prescribed as to what kind of information is given priority over others when archaeological information work evolves. The question is less about keeping up the binary of digital/non-digital than about articulating categories that are perceived to make a difference in the context of archaeology and archaeological information work.

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